NCERT PowerNotes

NEET Biology
Class 11 + 12

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I would like to take this opportunity to thank my book designing team Mr and Mrs Bhingare for their unstinted cooperation.

All the Best!

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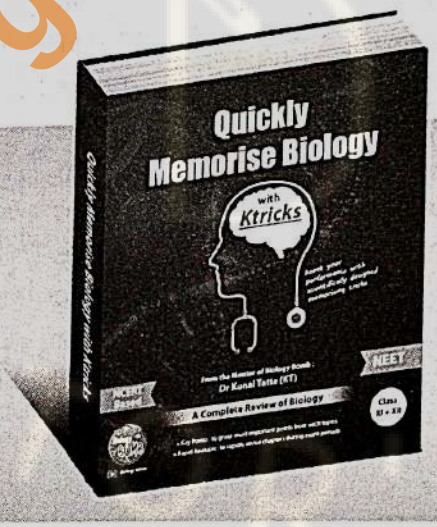

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01. Living World

Ernst Mayr : 'The Darwin' of the 20th century, pioneered the currently accepted definition of a biological species

What is 'living'?

Growth

- All living organisms Grow
- Growth is increase in cell number and increase in cell mass
- Plants : Growth is indefinite
- Animals : Growth is seen up to certain age, cell replacement continue
- Unicellular organism : grow by cell division
- Non Living : Mountains, boulders and sand mounds do grow.
- So Growth can not be considered as defining feature of living
- In majority of higher animals and plants, growth and reproduction are mutually exclusive events.
- In single cell organism , growth and reproduction is mutually inclusive event

Reproduction

- Living organisms can reproduce
- Unicellular organism : like bacteria, unicellular algae or Amoeba, reproduction is synonymous with growth, i.e., increases in number of cells.
- There are many organisms which do not reproduce (mules, sterile worker bees, infertile human couples, etc).
- Hence reproduction can not be considered as defining characteristic of living organisms.

Metabolism

- Metabolism means conversion of one chemical to another
- All plants, animals, fungi and microbes exhibit metabolism.
- Metabolic reactions can be demonstrated outside the body in cell-free systems (in vitro)
- Metabolic reaction can occur in living condition (inside cell, tissue, organs) and in non living condition (in vitro – test tube)
- Metabolic reaction inside cell is a defining feature and hence cellular organization is a defining feature

Consciousness

- It is the response of organism to surrounding
- All organisms therefore, are 'aware' of their surroundings
- Consciousness therefore, becomes the defining property of living organisms.
- Patient lying in coma is living or non living? Though patient lying in coma has lost consciousness, still considered as living because metabolic reactions are present

➢ For plants, scientific names are provided in International Code for Botanical Nomenclature (ICBN)

➢ For animals, scientific names are provided in International Code for Zoological Nomenclature (ICZN)

- Each scientific name has two components – the Generic name and the specific epithet.
- The system of providing a name with two components is called Binomial nomenclature
- This naming system is given by Carolus Linnaeus

Universal rules of nomenclature are as follows:

1) Biological names are generally in Latin and written in italics. They are Latinised or derived from Latin irrespective of their origin.
2) The first word in a biological name represents the genus while the second component denotes the specific epithet.
3) Both the words in a biological name, when handwritten, are separately underlined, or printed in italics to indicate their Latin origin.
4) The first word denoting the genus starts with a capital letter while the specific epithet starts with a small letter. It can be illustrated with the example of *Mangifera indica*

Classification is the process by which anything is grouped into convenient categories based on some easily observable characters. The scientific term for these categories is taxa.

Taxonomy

Taxonomy

It is the **process** of classification of any organism into suitable taxon

Steps

1. Characterisation (description)
2. Identification
3. Classification
4. Nomenclature

Systematic

- Systematics is systematic arrangement of organisms based upon evolutionary relationship between them
- Systematics = Taxonomy + Evolutionary relationship
- Linnaeus published a book Systema Naturae

Characterization (description)

- Collection of specimens
- Note down details (pentamerous, epipetalous etc)
- Maintain diary

Identification

- For identification, compare the specimen with already discovered specimen
- Specimen or methods that help in identification are called Taxonomic aids

1) Herbarium

- Herbarium is a store house of collected plant specimens that are dried, pressed and preserved on sheets
- These sheets are arranged according to a universally accepted system of classification
- The herbarium sheets also carry a label providing information about date and place of collection, English, local and botanical names, family, collector's name,

2) Botanical Gardens

- Exsitu conservation, collections of living plants
- Each plant is labelled
- Famous botanical gardens are :
  - Royal Botanical gardens are at Kew (England),
  - Indian Botanical Garden, Howrah (India)
  - National Botanical Research Institute, Lucknow (India).

3) Museum

- Collection of preserved plants and animal species
- Insects are preserved in boxes
- Generally Large animals like mammals, bird are preserved in museum

4) Zoological parks

- Live animals are kept in human protection in similar natural habitat
- Ex situ conservation

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- Help study food habits and behaviour

5) Key

- Taxonomic key help in correct identification
- Statements are in pair (couplet)
- Couplet have two contrasting statements (leads)
- Key is based on similarity and dissimilarity
- Keys are dichotomous
- Key is analytical in nature
- Separate taxonomic keys are required for each taxonomic category such as family, genus and species etc

Flora	Flora contains the actual account of habitat and distribution of **plants** of a given area.
Manual	Are specific, more detailed information for identification of **names of species** found in an area
Monograph	Monographs contain information on **any one taxon**
Catalogue	provide the **index** or list of the plant species found in a particular area

Classification

- Category and taxon
  - Category : Group of similar organisms
  - Taxon : It is such category to which some feature is attached
    : It is a Scientific term of category
- Taxonomic hierarchy: refers to the sequence of categories in increasing or decreasing order.

1) Species

- Group of similar organisms which can interbreed and produce fertile young ones
- Species are immutable (by Linnaeus)
- Allopatric and sympatric species
  - Allopatric species found in different geographical area
  - Sympatric species found in same geographical
- Keystone species
  - Important for survival of other species
  - A classic keystone species is a predator that prevents a particular herbivorous species from eliminating dominant plant species.

2) Genus

- Group of similar species
- For example, potato and brinjal are two different species but both belong to the genus Solanum.
- Lion (Panthera leo), leopard (P. pardus) and tiger (P. tigris) with several common features, are all species of the genus Panthera.

3) Family

- Group of related genera (Plant : aceae, animal : idea)
- Families are characterised on the basis of both vegetative and reproductive features of plant species.
- Family Solanaceae : Solanum, Petunia and Datura genera
- Family Felidae : Felis (cats), Panthera,
- Family Canidae : includes dogs

4) Order

- Group of related genera
- Polynomiales (based on foral character) : Convolvulaceae, Solanaceae families
- Carnivora : Felidae , Canidae

5) Class

- Group of related orders
- Class Mammalia : order Primata (monkey, gorilla and gibbon) . order Carnivora (Tiger, cat, Dog)

6) Phylum or division

- Ernst Haeckel coined the term Phylum
- Chordates (presence of notochord) : Mammal, fish, amphibian, reptiles

7) Kingdom

- All animals belonging to various phyla are assigned to the
- highest category called Kingdom Animalia.

As we go higher from species to kingdom, the number of common characteristics goes on decreasing.

Common Name	Biological Name	Genus	Family	Order	Class	Phythum / Division
Man	Homo sapiens	Homo	Hominidae	Primata	Mammalia	Chordata
Housefly	Musca domestica	Musca	Muscidae	Diptera	Insecta	Arthropoda
Mango	Mangifera indica	Mangifera	Anacardiaceae	Sapindales	Dicotyledonae	Angiospermae
Wheat	Triticum aestivum	Triticum	Poaceae	Polaes	Monocotyledonae	Angiospermae
Dog	Canis families	Canidae	Carnivora	Mammalia	Chordata	Animalia
Cat	Felis catus	Felidae	Carnivora	Mammalia	Chordata	Animalia
Tiger	Panthera tigris	Felidae	Carnivora	Mammalia	Chordata	Animalia
Lion	Panthera leao	Felidae	Carnivora	Mammalia	Chordata	Animalia
Leopard	Panthera pardus	Felidae	Carnivora	Mammalia	Chordata	Animalia
Potato	Solanum tuberosum	Solanaceae	Polymonaiales	Dicotyledonae	Angiospermae	Plantae
Brinjal	Solanum melongena	Solanaceae	Polymonaiales	Dicotyledonae	Angiospermae	Plantae

Kingdom
↑
Phylum or Division
↑
Class
↑
Order
↑
Family
↑
Genus
↑
Species

Trick :
Kids Prefer Candy Over Fride Green Spinach

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02. Biological Classification

Introduction

Aristotle classified living organism into plants (herb, shrub, tree) and animals (with and without red blood)

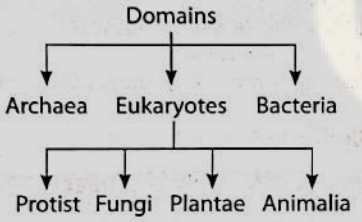
Linnaeus gave two Kingdom system of classification with Plantae and Animalia kingdoms

But, unlike Aristotle, Linnaeus divided kingdom into five levels: class, order, genus, species, and variety.

R.H. Whittaker proposed a Five Kingdom Classification Monera, Protista, Fungi, Plantae and Animalia.

Criteria used
1) cell structure,
2) body organisation,
3) mode of nutrition,
4) reproduction
5) phylogenetic relationships

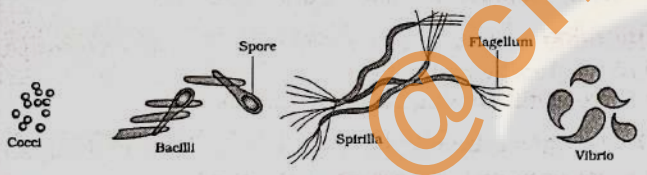
Three Domain system (by Carl wose) divides Monera into two domains



Chlamydomonas, Chlorella (earlier placed in Algae within Plants)
Paramecium and Amoeba placed under Protista

Kingdom of Monera

- Bacteria are the sole members of the Monera
- Groups: Spherical Coccus, the rod-shaped Bacillus, comma shaped - Vibrium and the spiral - Spirillum
- Shows most extensive nutritional diversity



Archaebacteria

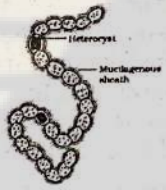
- Live in most harsh habitats
  - Salty areas (halophiles),
  - Hot springs (thermoacidophiles)
  - Marshy areas (methanogens)
- Differ from eubacteria in having a different
  - Cell wall structure (pseudopeptidoglycan)
  - Plasma membrane is also Single lipid layer
- **Methanogen**
  - Present in the gut of cows and buffaloes etc
  - Produces methane from cow dung

Eubacteria

Photosynthetic autotrophs

- **Cyanobacteria**
- True bacteria having Peptidoglycan cell wall
- Cyanobacteria are also called as blue green algae but they are not eukaryotes
- Surrounded by: Mucilaginous sheath
- Specialized cell: Heterocyst
- Heterocyst can fix atmospheric nitrogen with the help of nitrogenase enzyme .
- Cycas Coralloid roots show symbiotic asso with Cyanobacteria

Examples:
Spirulina (single cell protein)
Oscillatoria
Nostoc (Can fix N_2)
Anabaena (Can fix N_2)



SONA

Chemosynthetic autotrophs

Certain bacteria oxidise various inorganic substances such as nitrates, nitrites and ammonia and use the released energy for their ATP production.

$NH_4^+ \xrightarrow{\text{Nitrosomonas, Nitrosococcus}} NO_2$	$NO_2 \xrightarrow{\text{Nitrobacter, Nitrocystis}} NO_3$

Heterotrophs

- Saprophytes feed on dead, decaying or decomposed organic matter E.g., Lactobacillus
- Parasitic: Typhoid, Cholera, tetanus, citrus canker
- Symbiotic: Rhizobium, Frankia

Reproduction

- Asexual reproduction: Fission
- Sexual reproduction: Involve DNA transfer from one bacterium to the other.

Mycoplasma

- Lack a cell wall, smallest living cells known
- Survive without oxygen, pathogenic

Kingdom Protista

- Protist are **single celled eukaryotes**
- Eukaryotic features
  - Well defined nucleus
  - Membrane-bound organelles.
  - Habitat - Aquatic
- Reproduction:
  - Asexual and Sexual through gametes

Chrysophytes

- Includes
  - Diatoms and golden algae (desmids)
  - Photosynthetic organism
- Cell wall
  - Cell wall forms two overlapping structure like **soap box**
  - Wall are embedded with **silica**
- Flagella
  - **Flagella is absent**, move passively– plankton
- Cells die and settle down
  - Silica cell wall deposits found at the sea bed referred to as 'diatomaceous earth'.
  - Use in polishing, filtration of oils and syrups.
- Chief producers of ocean

Dinoflagellates

- Dino means 2, flagella (one longitudinal and one transverse flagella)
- Photosynthetic organism
- Cell wall is made up of **cellulose plates**
- Red dinoflagellates (Example: Gonyaulax) undergo such rapid multiplication that they make the sea appear red **(red tides).**

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Diana ne red dress pehna

- ***Toxins*** released by such large numbers may even kill other marine animals such as fishes

Euglenoids

- Fresh stagnant water
- **Lack cell wall**
- Instead of cell wall they have protein rich layer called ***pellicle***
- Pellicle gives them flexibility
- They are Autotroph in presence of sunlight and heterotroph in absence of sunlight
- Euglena reproduce only asexually (binary fission). Sexual reproduction is absent

Slime Mold

- **Saprophytic** Protist
- **Lack cell wall**
- Moves along decaying twigs and leaves
- Under Favourable condition: they form an aggregation called ***plasmodium***
- Under unfavorable condition : form fruiting bodies bearing spores at their tips

Protozoans

- All protozoan are heterotrophs, no cell wall

Amoeboid P.	Move by Pseudopodia E.g., Entamobea (dysentry)
Ciliated P.	Move by cilia Contractile vacuole - osmoregulation E.g., Paramecium
Sporozoans	Spore like state in life cycle E.g., Plasmodium (malaria)
Flagellated P	Move by flagella E.g., Trypanosoma - sleeping sickness

Viruses

Basic Features

- Non cellular organism
- Either DNA or RNA present, never both
- Metabolic reaction absent (glycolysis is also absent)
- Obligate parasites

Structure

Virus is made up of RNA or DNA

Discoveries

Ivanovsky	Studied mosaic disease of tobacco, recognised certain microbes smaller than bacteria
Beijerinck	called extract of mosaic disease of tobacco as ***Contagium vivum fluidum*** (infectious living fluid)
Stanley	showed viruses are made up of proteins and it can be **crystalised**

Virus that infects

Viruses that infect Planet Cell	Viruses that infect Animal Cell	Viruses that infect Bacterial Cell
ss RNA virus	ss RNA virus ds RNA virus ds DNA ~~ss DNA~~	ds RNA virus ***Bacteriophage***

Viral diseases

mumps, small pox, herpes, influenza. AIDS, common cold

Viroid

- Discovered by T.O. Diener
- Protein coat absent
- Have Single stranded **RNA**
- Smaller than viruses
- Low molecular weight

} **Differs from virus**

- Cause **Potato spindle tuber disease**

Prions

- Prions are **abnormally folded proteins**
- Causes neurological disease
- Bovine spongiform encephalopathy (BSE) commonly called mad cow disease in cattle and
- Cr–Jacob disease (CJD) in humans

Lichens

- **Symbiotic associations** i.e., mutually useful associations, between algae and fungi
- Algal component: Phycobiont
- Fungal component: Mycobiont
- Algae gives food to fungus and Fungus absorb mineral, water for algae
- Useful as **Pollution indicator**

Kingdom Fungi

Significance

- Edible mushroom, Poisonous toadstool are fungi
- Wheat rust is caused by Puccinia
- Penicillium fungus produces Penicillin antibiotics
- Unicellular fungus, Yeast is used to make bread and beer

Habitat

- Prefer warm and humid environment
- Found in air,water, soil, animal, plant (cosmopol-)

Nutrition

- All fungi are heterotrophs
- Saprophytic, Parasitic, Symbiotic (Lichen)

Body Organisation

- Fungi are filamentous except yeast (unicellular)
- These filaments are called **hyphae**
- Network of hyphae is known as **mycelium**
- Hyphae can be coenocytic or Septate hyphae
- Cell wall is made up of **Chitin**

Sexual reproduction

3 steps

1. Plasmogamy: Fusion of protoplasm
2. Dikaryon : a pair of associated but unfused haploid nuclei are visible
3. Karyogamy: Fusion of nucleus

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	Phycomycetes	Ascomycetes	Basidiomcetes	Deuteromycetes
Habitat	Aquatic, obligate plant parasite	Decaying substance, grow on dung (coprophilous)	Grow in soil, parasitic Bracket fungi, puff balls	Decomposers
Mycelium	Aseptate, coenocytic	Septate and branched	Septate and branched	Septate and branched
Vegetative	Fragmentation	Fragmentation, fission and budding	Fragmentation	Fragmentation
Asexual reproduction	Endogenous spore Motile (zoospore) Non motile (aplanospore)	Conidia (asexual non motile exogenous spore)	Absent	Conidia (exogenous)
Sexual repro	Gametes : iso, aniso~ Endogenous zygospore	Endogenous spore (Ascospore)	Sex organs absent, exogenous basidiospore	Sexual reproduction absent, known as imperfect fungi
	Dikaryon stage not visible			----------
	Rhizopus (bread mould), Albugo (mustard fungi), Mucor	Yeast (brewer's) Penicillium (antibiotic) Neurospora (genetic study), Truffle and Morels	Agaricus (mushroom) Ustilago (smut) Puccinia (rust fungus) Puff ball, Toad stool	Colletotrichum Alternaria Trichoderma **CAT**

Characters	Five Kingdom				
	Monera	**Protisia**	**Fungi**	**Plante**	**Animalia**
Cell type	Prokaryotic	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Cell wall	Noncellulosic (Polysaccharide + amino acid)	Present in some	Present with chitin	Present (cellulose)	Absent
Nuclear membrane	Absent	Present	Present	Present	Present
Body organisation	Cellular	Cellular	Multicellular / loose tissue	Tissue / organ	Tissue / organ / organ system
Mode of nutrition	Autotrophic (chemosynthetic and photosynthetic) and Heterotrophic (saprophytic / parasitic)	Autotrophic (Phtosynthetic) and Heterotrophic	Heterotrophic (Saprophytic / Parasitic)	Autotrophic (Photosynthetic)	Heterotrophic (Holozoic / Saprophytic etc,)

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03. Plant Kingdom

Algae

Cholorophyceae (Green alage)	Phaeophycae (Brown alage)	Rhodophycae (Red alage)
Mainly fresh water	Mainly marine	Mainly marine
Unicellular • Chlorella (non motile) • Chlamydomonas (motile) **Colonial** • Volvax **Filamentous** • Cladophora, Ulothrix	Multicellular Frond, stipe, Holdfast E.g. Kelp Filamentous E.g. Ectocarpus	Multicellular
Cell wall		
Cellulose Pectose	Cellulose Outer align	Cellulose Outer carageen
Pigment		
Chl a Chl b	Chl a Chl c Fucoxanthin	Chl a Chl d Phycoerythrin
Storage Forms		
Starch	Laminarin mannitol	Floridian starch (similar to amylopectin and Glycogen)
Vegetative Reproduction		
Fragmentation	Fragmentation	Fragmentation
Asexual Reproduction		
Zoospore : 2-8 apical, equal flagella	Zoospore : lateral, unequal, flagella	Non motile spore (aplanospore)
Sexual Reproduction		
Isogamous **Anisogamous** • Eudorina **Oogamous** • Chara, Volvox	**Isogamous** **Anisogamous** **Oogamous** • Fucus	**Oogamous**
Chlorella, Volvox, Chlamydomonas, Ulothrix, Spirogyra, Eudorina, Chara	Ectocarpus, Kelp Laminaria, Fucus Sargassum, Dictyota	Polysiphonia, Porphyra, Gracilaria, Gelidium

Isogamous : male and female gamete have similar morphology

Anisogamous : male & female gametes have dissimilar morphology

Oogamous : small and motile male gamete, large non motile female gamete

- **Exceptions:**

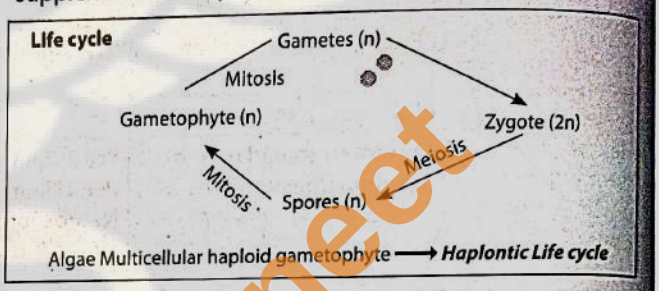
Spirogyra (Green algae), have non motile gamete

In red algae, both spores and gametes are non-motile

- **Special feature**
  - Pyrenoid:
    - Found in green algae,
    - Storage body in the chloroplast
    - Made up of Protein covered with starch

Economic importance

- Algin (brown algae) and carrageen (red algae) produce large amounts of hydrocolloids (water holding substances) which are used commercially.
- Sargassum, Laminaria, Porphyra: used as food **(SarLa Pasta food khati hai)a**
- Gelidium and Gracilaria are used as agar to grow microbes and in preparations of ice-creams and jellies.
- Chlorella a unicellular alga rich in proteins is used as food supplement even by space travellers.



Exception:

Polysiphonia, Ectocarpus, Kelp: Haplodiplontic life cycle

Fucus: Diplontic life cycle

Bryophytes

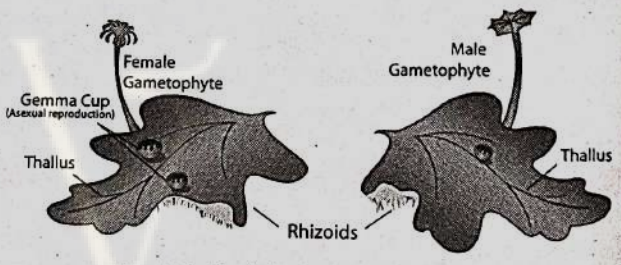
- Bryophytes include the various mosses and liverworts
- Bryophytes are also called amphibians of the plant kingdom because they are dependent on water for sexual reproduction
- Occur in damp, humid and shaded localities
- Structure
  - Main Plant body is gametophyte
  - Plant body is thallus; possess root-like, leaf-like or stem-like structures

Liverworts (e.g. Marchantia)

Asexual Reproduction:

Fragmentation and Gemma Buds

Gemma are green, multicellular, asexual buds, which develop in small receptacles called Gemma cups located on the thalli. The Gemma become detached from the parent body and germinate to form new individuals



Female thallus and Male thallus of Marchantia

Sexual reproduction:

Gametophyte ⟶ develops archegoniophore and antheridiophore on which develops antheridium and archegonium respectively ⟶ The biflagellate antherozoids (water) fuses with the egg ⟶ zygote ⟶ multicellular body called a sporophyte ⟶ The sporophyte is not free-living but attached to the photosynthetic gametophyte and derives nourishment from it ⟶ Sporophyte on meiosis produce Spores (n) ⟶ gametophyte

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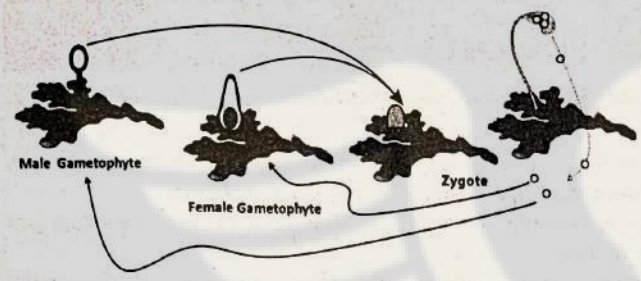
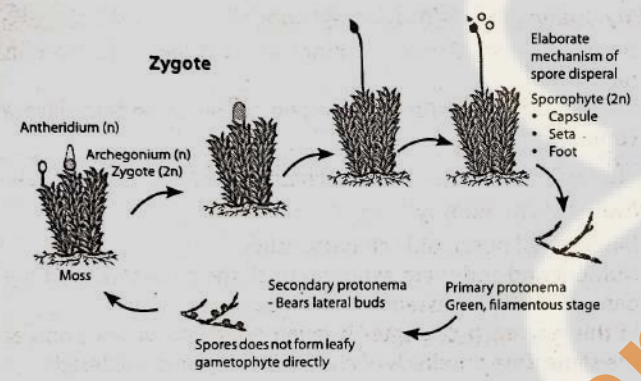


Mosses (Funaria, Polytrichum and Sphagnum)

- Asexual Reproduction: Fragmentation & budding in protonema
- Sexual reproduction in moss
- Here spore do not form gametophyte directly instead it forms creeping, green, branched and frequently filamentous stage called Protonema ⟶ Protonema develops lateral buds ⟶ Buds develops to forms leafy stage



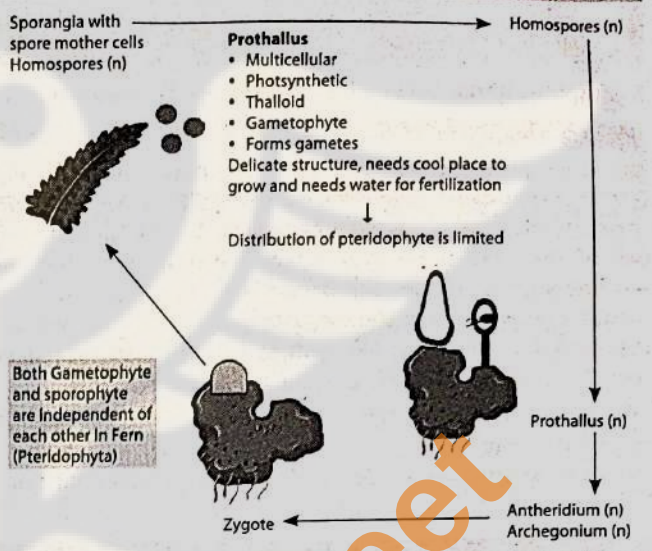
Liverwort	Moss
Plant body creeping	Plant body is erect
Rhizoid - Unicellular	Rhizoid multicellular
Sporophyte : less elaborate	Sporophyte : more elaborate
Spore disperal mechanism absent	Elaborate spore disperal (pop sound)
Reproduction : Fragmentation, Gemma cup	Reproduction : Fragmentation Budding in protonema
Spore directly give thallus	Spore Protonema ⟶ (filamentous stage) ⟶ secondary protonema (hv lateral bud) ⟶ leafy stage

Pteridophytes

- The Pteridophytes include horsetails and ferns
- They are the first terrestrial plants to possess vascular tissues
- Found in cool, damp, shady places
- Main plant body is a sporophyte
- Plant differentiated into root, stem and leaves

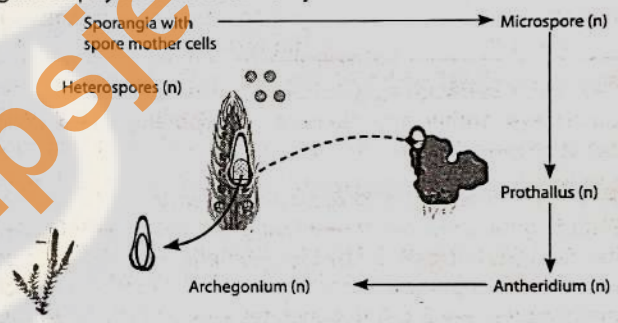
Fern	Selaginella
Leaves are large (Macrophylls)	Leaves are small (Microphylls)
Do not bear cone	Sporophyll forms cone/strobili (also +nt in Equisetum)
Spores are of similar kind : Homosporous	Produce spores of different kind : Heterosporous (also +nt in salvinia)

Sexual reproduction in fern



Sexual reproduction in salvinia

- Selaginella and Salvinia are Heterosporous plants
- The female gametophytes in these plants are retained on the parent sporophytes for variable periods
- In **Heterosporous** pteridophytes, the development of the zygotes into young embryos takes place within the female gametophytes. This event is a ***precursor to the seed habit***



Classification:

Psilopsida (Psilotum); Lycopsida (Selaginella, Lycopodium), Pteropsida (Dryopteris, Pteris, Adiantum)
Sphenopsida (Equisetum)

Economic importance

Sphagnum (moss), provide peat that can be used as fuel, and as packing material for trans-shipment of living material because of their capacity to hold water

Gymnosperms

- The gymnosperms (gymnos : naked, sperma : seeds) are plants in which the ovules are not enclosed by any ovary wall a
- Sequoia is one of the tallest tree species

	Cycas	Pinus
Leaf	Compound leaf	Needle shape leaf (no reduce transpiration)
Stem	Unbranched	Branched
Stem	Tap root	Tap root
Specified root	Coralloid root shows association with cyanobacteria to fix N_2	Pinus shows association with fungus : Mycorhiza
Sexuality	Cycas is unisexual plant	Pinus is a bisexual plant

Tg:- @chanpsiee_neet

- Gymnosperms are Heterosporous plants

Microspores

Microsporophyll form male cone ⟶ Microsporangia ⟶ Microspore mother cell ⟶ Microspores ⟶ Pollen grain

Megaspores

Megasporophyll form female cone (Megasporophyll do not form cone in cycas) ⟶ Megasporangia (ovule) ⟶ Ovule is composed of nucellus bounded by single integument ⟶ one of the cells of nucellus act as megaspore mother cell ⟶ megaspore mother cell divides meiotically to form four megaspores ⟶ one of the megaspores develop as functional megaspore ⟶ a multicellular female gametophyte ⟶ female gametophyte bears two or more archegonia

- Bryophyte & Pteridophyte ⟶ independent male & female gametophyte
- Gymnosperms ⟶ Gametophyte is dependent on sporophyte

Angiosperm

Ovule develops inside ovary

Angiosperms range in size from the smallest Wolffia to tall trees of Eucalyptus

Monocots	Dicots
Seeds have single cotyledons	seeds having two cotyledons
Parallel venation in leaves	reticulate venations in leaves
Trimerous flowers	tetramerous or pentamerous flowers

Male sex organs

Stamen ⟶ anther and filament ⟶ sporangia ⟶ Pollen mother cell ⟶ Pollen

Female sex organs

- Pistil Stigma, style, ovary ⟶ Ovary has ovules ⟶ Ovule is has nucellus enclosed by two integument ⟶ one of the cell of nucellus act as megaspore mother cell ⟶ forms 4 haploid megaspores ⟶ 3 cell degenerates ⟶ one divide to form the **embryo sac** ⟶ Each embryo-sac has a three-celled egg apparatus – one egg cell and two synergids, three antipodal cells and two polar nuclei

Gymnosperm	Angiosperms
Double fertilization absent	Double fertilization present
Endosperm (n)	Endosperms (3n)
Ovule: single integument	Ovule: two integuments
Wind pollination	Air, water, insect pollination

Algae	Bryophyte	Pteridophyte	Gymnosperms and Angio-sperms
Multicellular green long-lived gametophyte	Multicellular green long-lived gametophyte	Green multicellular short lived (Prothallus) gametophyte	Non green dependent (Pollen grain) gameto ~
Sporophyte is single celled zygote	Multicellular, non-green sporophyte dependent on gametophyte	Multicellular green long lived sporophyte	Multicellular long lived green sporophyte
Dominant phase: gametophyte	Dominant phase: gametophyte	Dominant phase : Sporophyte	Dominant phase : Sporophyte
Haplontic life cycle	Haplo diplontic life cycle	Haplo dipontic life cycle	Diplontic life cycle

- ➢ Polysiphonia, Ectocarpus and Kelp shows Haplo Diplontic life cycle
- ➢ Fucus shows Diplontic life cycle

Artificial system of classification

- given by Linnaeus
- used only gross superficial morphological characters such as habit, colour, number and shape of leaves, etc.
- based mainly on vegetative characters or on the androecium structure
- gave equal weightage to vegetative and sexual characteristics;
- not acceptable since the vegetative characters are more easily affected by environment

Natural classification systems

- Given by George Bentham and Joseph Dalton Hooker.
- Considered not only the external features, but also internal features, like ultra-structure, anatomy, embryology and phytochemistry.
- Considered characters which are permanent and do not change with the environment

Phylogenetic classification systems

- based on evolutionary relationships between the various organisms
- assumes that organisms belonging to the same taxa have a common ancestor
- important when there is no supporting fossil evidence.

Numerical Taxonomy

- based on all observable characteristics
- Number and codes are assigned to all the characters and the data are then processed with computers
- In this way each character is given equal importance and at the same time hundreds of characters can be considered.

Cytotaxonomy

- based on cytological information like chromosome number, structure, behaviour

Chemotaxonomy

- uses the chemical constituents of the plant to resolve confusions,

Tg:- @shanpsee_neet

04. Animal Kingdom

Level of Organization	
Cellular	Porifera
Tissue	Coelenterata and Ctenophora
Organ level	Platyhelminthes
Organ system	Some Platy, Aschelminthes -- chordate

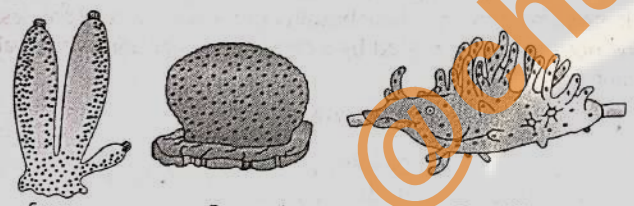
Symmetry	
Porifera	Asymmetry
Coelenterata, Ctenophora, Echinodermata adult	Radial symmetry
Annelid, Arthropoda, etc Echinodermata larva	Bilateral symmetry

Germ Layer	
Porifera	No germ layer
Coelenterata, Ctenophora,	Diploblastic
Platyhelminthes	Triploblastic acoelomate
Aschelminthes	Triploblastic Psudocoelom
Annelid--- Chordate	Triploblastic Eucoelome

Metameric segmentation
Annelids, Arthropoda, Chordates

Porifera

Habitat : Mostly marine (spongilla: fresh water)
Symmetry : Asymmetrical
Germ layer : --
Level of orgⁿ : Cellular
Digestion : Intracellular
Sex : Bisexual, Hermaphrodite, Monoceous
Fertilization : Internal, asexual reprodn : fragmentation
Development : Indirect
Features : Spongocoel, osculum, choanocyte (collar cell)



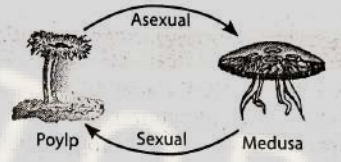
Sycon Euspongia Spongilla

Coelenterata (Cnidaria)

Habitat : Mostly marine, sessile/ free living
Symmetry : Radial symmetry
Germ layer : Diploblastic
Level of orgⁿ : Tissue
Digestion : Extracellular and intracellular
Sex : Bisexual, Hermaphrodite, Monoceous
Fertilization : Sexual and asexual
Development : Indirect
Features : Gastrovacular cavity (blind sac)
: Cnidoblasts or cnidocytes on tentacles
: Corals have a skeleton composed of Calcium carbonate

Phenomenon of alteration of generation, polyp and medusa is called ***Metagenesis.*** *Eg. Obelia*

Obelia obeys the rule of metagenesis



Exclusively polyp Eg Hydra, Adamsia — *Exclusively medusa form Aurelia or jelly fish*

Examples: Physalia (Portuguese man-of-war), Adamsia (Sea anemone), Pennatula (Sea-pen), Gorgonia (Sea-fan) and Meandrina (Brain coral)

Ctenophora

Special features:
- Eight external rows of ciliated **comb plates**
- Bioluminescence

Cteno matlab teen : teen comb plated balls bioluminance show karte hai

Habitat : Exclusively marine
Symmetry : Radial symmetry
Germ layer : Diploblastic
Level of orgⁿ : Tissue
Alimentary C : Blind sac
Digestion : Extracellular and intracellular
Sex : Bisexual, Hermaphrodite, Monoceous
Fertilization : Only Sexual
Development : Indirect

Platyhelminthes

Habitat : Endoparasite
Symmetry : Bilateral symmetry
Germ layer : Triploblastic
Level of orgⁿ : Organ and organ system
Coelom : Acoelomate
Alimentary C : Blind sac
Digestion : Absorb digested food
Excretion : Flame cell
Sex : Bisexual, Hermaphrodite, Monoceous
Reproduction : Sexual and asexual

Ctenophora (Pleurobrachia)

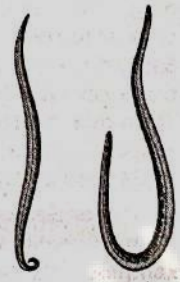
Platy ke plate me flame cells hote hai

Special features :
- Hooks and suckers
- Planaria possess high regeneration capacity
- Dorso-ventrally flattened body – k/a Flatworms
- Examples: Taenia (Tapeworm), Fasciola (Liver fluke)

Note : The human liver fluke (a trematode parasite) depends on two intermediate hosts (a snail and a fish) to complete its life cycle.

Aschelminthes (Round worm)

Habitat : Aquatic and terrestrial or parasitic
Symmetry : Bilateral symmetry
Germ layer : Triploblastic
Level of orgⁿ : Organ system
Coelom : Psudocoelomate
Alimentary C : Blind sac
Digestion : Absorb digested food
Excretion : Rennet cell
Sex : Sexes separate
Reproduction : Sexual
Fertilization : Internal



Male Female
Roundworms

Aschelminthes me pehli baar sex separate hue

Special features :
- Muscular pharynx
- Sexual dimporphism (male and female) shows different morphological characteristics

Tg:- @handsome_neet

Examples : Ascaris (Round Worm), Wuchereria (Filaria worm), Ancylostoma (Hookworm).

Common for Annelida to hemichordata

Symmetry	:	Bilateral symmetry
Germ layer	:	Triploblastic
Level of orgⁿ	:	Organ system
Coelom	:	Coelomate
Sex	:	Sexes separate
Reproduction	:	Sexual
Fertilization	:	External (internal in Arthropoda)
Development	:	Indirect

Annelida

Habitat	:	Aquatic and terrestrial
Digestion	:	Absorb digested food
Excretion	:	Nephridia
Sex	:	Sexes separate (Nereis)
	:	Bisexual (Earthworm and leech)

Special features
- Nereis posses s lateral appendages, **parapodia**
- **Closed** circulatory system
- Excretion by nephridia
- Moist cutaneous respirationw
- Metameric segmentation (Annelids, Arthropoda, Chordata)

Arthropoda

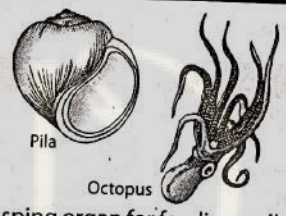
Habitat	:	Aquatic , terrestrial , air
Respiration	:	Gills. Book lungs, tracheal system
Excretion	:	Malphigian tubule
Circulation	:	Open circulation

Special features
- Arthropoda is the largest phylum
- Chitinous exoskeleton
- Jointed appendages

Examples: Economically important insects – Apis (Honey bee), Bombyx (Silkworm), Laccifer (Lac insect) Vectors – Anopheles, Culex and Aedes (Mosquitoes) Gregarious pest – Locusta (Locust) Living fossil – Limulus (King crab).

Mollusca

Special features
- Body has head, muscular foot and visceral hump
- Body is covered by a calcareous shell
- Soft skin forms ***mantle*** over the visceral hump



- The mouth contains a file-like rasping organ for feeding, called ***radula***.
- Respiration and excretion by gills

Mollusca ke mouth me radula hota hai

Examples: Pila (Apple snail), Pinctada (Pearl oyster), Sepia (Cuttlefish), Loligo (Squid), Octopus (Devil fish), Aplysia (Seahare), Dentalium (Tusk shell) and Chaetopleura (Chiton).

Echinodermata

Special features
- Exclusively marine
- Adult: radial symmetry, Lava : Bilateral symmetry
- Echinodermata means spiny skin
- Excretory system absent
- Locomotion, transport of food and excretion is by water vascular system

Water ka echo Echinodermata sunata hai

Examples: Asterias (Star fish), Echinus (Sea urchin), Antedon (Sea lily), Cucumaria (Sea cucumber) and Ophiura (Brittle star).

Hemichordata

Special features
- Exclusively marine, worm like
- **Proboscis**, a collar and a long trunk
- Stomochord present near mouth

Examples: Balanoglossus and Saccoglossus.

Chordata

Chordates	Non-chordates
Notochord present	Notochord absent
Centrual nervous system is dorsal, hollow and single	Centra nervous system is ventral, solid and double
Pharynx perforaed by gill slits	Gill slits are absent
Heart is ventral	Heart is dorsal (if present)
A post-anal tail is present	Post-anal tail is absent

Urochordata	Cephalochordata
Notochord present only in tail	Notochord extend from tail to head
Notochord Present only in larva	Notochord Present throughout life
Salpa, Ascidia, Doliolum (SAD)	Branchiostoma (Amphioxus / Lancelet)

Vertebrata

All vertebrates are chordates but all chordates are not vertebrates. The notochord is replaced by a cartilaginous or bony vertebral column in the adult.

Vertebrata
- Division
  - Agnatha (lacks jaw)
    - Class
      1. Cyclostomata
  - Gnathostomata (bears jaw)
    - Super Class
      - Pisces (bear fins)
        - Class
          1. Chondrichthyes
          2. Osteichthyes
      - Tetrapoda (bear limbs)
        - Class
          1. Amphibia
          2. Reprilia
          3. Aves
          4. Mammals

Cyclostomata

Cyclo : Circular, Stomata: mouth

Habitat	⟶	Ectoparasite
Feature	⟶	Circular mouth without jaw
Respiration	⟶	6 – 15 pairs of gills slits

Tg:- @chanpslee_neet

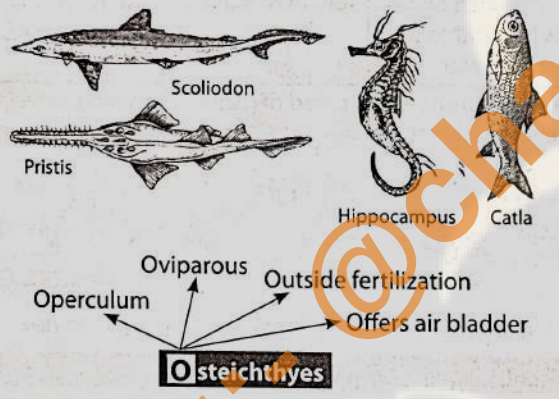
Vertbl column ⟶ Cartilaginous
Circulation ⟶ Close circulation
Body lacks ⟶ Scales and paired fins absent
Development ⟶ Indirect
Examples ⟶ Petromyzon (Lamprey)
⟶ Myxine (Hagfish)

Special features

Cyclostomes are marine but Migrate to fresh water for spawning. After spawning, within few days, they die. Their larvae, after metamorphosis, return to the ocean.

Pisces

Chondrichthyes	Osteichthyes
Marine	Marine and fresh water
Mouth : ventral	Mouth : terminal
Gills not covered	Gils covered with operculum
Air bladder is absent	Air bladder is present
Casper present	Casper absent
Placoid scales	Cycloid scales
Viviparous	Oviparous
Internal fertilization	External fertilization
Direct development	Direct development
Scoliodon (Dog fish), Pristis (Saw fish), Carcharodon (Great white shark), Trygon (Sting ray)	Marine – Exocoetus (Flying fish), Hippocampus (Sea horse); Freshwater – Labeo (Rohu), Catla (Katla), Clarias (Magur); Aquarium – Betta (Fighting fish), Pterophyllum (Angel fish)

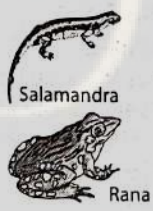


Chondrichthyes Special features

Trygon: Poison sting | Electric organs : Torpedo

Amphibian

Habitat ⟶ Terrestrial / aquatic
Heart ⟶ Three chambered
Respiration ⟶ Gills, Lungs, skin
Sex ⟶ Separate
Fertilization ⟶ External
Parity ⟶ Oviparous
Development ⟶ Indirect



Special features

- Tympanum present, Moist skin is without scales
- Alimentary canal, urinary and reproductive tracts open into a common chamber called cloaca which opens to the exterior
- Examples: Bufo (Toad), Rana (Frog), Hyla (Tree frog), Salamandra (Salamander), Ichthyophis (Limbless amphibia).

Reptiles

Habitat ⟶ Terrestrial / aquatic
Heart ⟶ 3 chambered (crocodile 4 chamber)
Sex ⟶ Separate
Fertilization ⟶ Internal
Parity ⟶ Oviparous
Development ⟶ Direct

Special features

Skin is dry with scales

Examples: Chelone (Turtle), Testudo (Tortoise), Chameleon (Tree lizard), Calotes (Garden lizard), Crocodilus (Crocodile), Alligator (Alligator). Hemidactylus (Wall lizard), Poisonous snakes – Naja (Cobra), Bangarus (Krait), Vipera (Viper)

Char feature ⟶ Feathers (Ostrich – Flightless)
Fore limb ⟶ Modified to wings
Hind limbs ⟶ for walking, have scales
Bones ⟶ Pneumatic
Digestive track ⟶ Crop and gizzard present
Heart ⟶ Four chambered
Respiration ⟶ Lungs with air sacs
Parity ⟶ Oviparous
Fertilization ⟶ Internal
Development ⟶ Direct
Regulators ⟶ Homeothermus (warm blooded)

Examples :

Corvus (Crow), Columba (Pigeon), Psittacula (Parrot), Struthio (Ostrich), Pavo (Peacock), Aptenodytes (Penguin), Neophron (Vulture)

Mammals

Char feature ⟶ Mammary glands
Body cover ⟶ Hair
Teeth ⟶ Heterodont
Regulators ⟶ Homeothermus (warm blooded)
Cervical vertebra ⟶ 7 in numbers

Examples:

Oviparous-Ornithorhynchus (Platypus); Viviparous - Macropus (Kangaroo), Pteropus (Flying fox), Camelus (Camel), Macaca (Monkey), Rattus (Rat), Canis (Dog), Felis (Cat), Elephas (Elephant), Equus (Horse), Delphinus (Common dolphin)

False Fishes		
Jelly fishes	Aurelia	Coelenterata
Silver fish	---	Artropoda
Cuttle fish	Sepia	Mollusca
Devil fish	Octopus	Mollusca
Star fish	Asterias	Echinodermata
Hagfish	Myxine	Cyclostomata

Tg: @chanpsjee_neet

05. Morphology of Flowering Plants

- Katherine Esau : received awards for work on plant anatomy
- Morphology refers to external structure

The Root

Types of Roots

Tap roots	Fibrous roots	Adventitious roots
Radicle gives rise to primary root which grows inside the soil. Branches of primary roots forms secondary, tertiary, etc. roots	Primary root is short lived. It is replaced by roots which originate from the base of the stem	roots arise from parts of the plant other than the radicle
Dicot root	Monocot root	Grass, Monstera, banyan tree

Regions of the Root

Regions	Features
Region of meristematic activity	cells of this region are very small, thin-walled and with dense protoplasm, divide repeatedly
Region of elongation	Cells in this region undergo rapid elongation responsible for the growth of the root in length.
Region of maturation	Cells in this region are differentiated and mature cells This region gives rise to root hairs

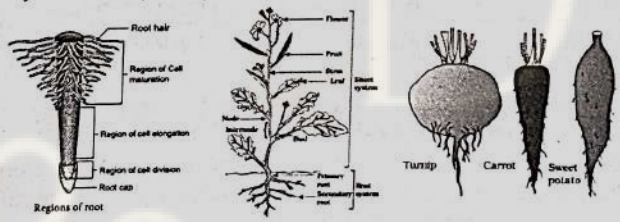
Root is covered at the apex by : root cap

Modifications of Root

Root modification	Examples
Tap root (Storage)	Carrot, turnip
Adventitious root (Storage)	Sweet potato, Asparagus
Prop root (Support)	Banyan tree
Stilt root (support)	Maize sugarcane
Pneumatophores (Respiration)	Rhizophora (Marshy area and Halophytes)

Functions of roots

- Absorption of water and minerals,
- Providing a proper anchorage to the plant,
- Food storage
- Synthesis of plant growth regulators (auxin and cytokinin)



The Stem

- Develops from the plumule
- The stem bears nodes and internodes.
  - Nodes : leaves are born at nodes
  - Internodes : portions between two nodes
- Stem bears buds
- Apical buds : Involve in primary growth of plant
- Axillary (lateral) buds : develops into branches or flowers, leaf petiole is attached here

Modifications of Stem

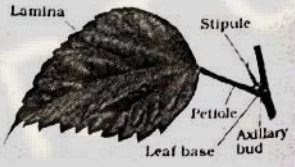
Modified stem	Function	Examples
Tendril (axillary buds)	Climb	cucumber, pumpkins, watermelon grapevines
Stem swollen	Food storage	Potato , ginger, turmeric, zaminkand, Colocasia
Thorns (axillary buds)	Protection	Citrus, Bougainvillea
Flat stem (Phylloclade)	Photosynthesis	Opuntia
Fleshy /cylindrical stem	Photosynthesis	Euphorbia
Underground Stem (Runner)	Spread to new niche	grass and strawberry
Stem arch downward (Stolon)	Spread of plant	Mint and Jasmine
Lateral branch nodes forms leaf and roots (offset) in water	Spread of plant	Pistia and Eichhornia
Lateral underground branches (suckers)	Spread of plant	banana, pineapple Chrysanthemum

The leaf

- Develops at the node and bears a bud in its axil. The axillary bud later develops into a branch
- Leaves originate from shoot apical meristems
- Arrangement of leaf : Acropetal order

Parts of leaf

- Leaf base
  - Leaf is attached to the stem by the leaf base
  - Leaf base bears small leaf like structures called stipules
  - Monocots : Sheath covers leaf base
  - Leguminous plants : Swollen leafbase (pulvinus)
- Petiole
  - Petiole help hold the blade to light – flutter with wind – cool down leaf
- Lamina or the leaf blade
  - Have middle prominent vein (mid rib) and venlets



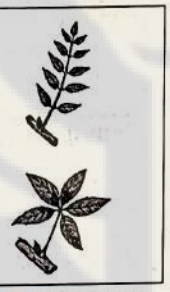
Tg:- @chanpsjee_neet

Types of Leaves

- Simple leaf
  - Lamina is entire or when incised, the incisions do not touch the midrib
- Compound Leaf
  - Incisions of the lamina reach up to the midrib breaking it into a number of leaflets.

Types of compound leaf

Pinnately compound leaf	Palmately compound leaves
Leaflets are present on a common axis, midrib called as Rachis	The leaflets are attached to petiole
E.g., neem	E.g., silk cotton



Phyllotaxy

Phyllotaxy is the pattern of arrangement of leaves on the stem or branch.

Phyllotaxy	Feature	Examples
Alternate Phyllotaxy	single leaf arises at each node in alternate manner	Sun flower, mustard China rose
Opposite Phyllotaxy	pair of leaves arise at each node and lie opposite to each other	Calotropis, guava
Whorled Phyllotaxy	more than two leaves arise at a node and form a whorl	Alstonia

Alternate Type Opposite Type Whorled Type

Modifications of Leaves

Modification of leaf	Examples
Leaf Tendril	Peas
Leaf Spines	Cacti
Fleshy Leaves	Onion, Garlic
Photosynthetic Petiole	Australian acacia
Insectivorous Plant	Pitcher plant, Venus fly trap

The Inflorescence

Inflorescence : Arrangement of flower on floral Axis

Racemose Inflorescence	Cymose Inflorescence
Floral axis have indefinite growth	Floral axis terminates into flower
Old flower at base – young flower at top	Old flower at top young at base
Acropetal - Brassicaceae Fabaceae	Basipetal

BF ke liye Ye Race unlimited hai : Racemose – indefinite : B and F

The flower

- The flower is the reproductive unit in the angiosperms
- Four parts: calyx, corolla, androecium and gynoecium.
- Calyx and corolla ⟶ accessory organs
- Androecium and gynoecium ⟶ reproductive organs

Type	Features
Bisexual Flower	Both androecium (stamen) and gynoecium present (Pistil)
Unisexual Flower	Staminate Flower : Stamen present, pistil absent Pistillate Flower : Pistil present, stamen absent

Symmetry	Definition	Example
Actinomorphic (Radial symmetry)	Flower can be divided into two equal radial halves by any radial plane	Mustard, Datura, Chilli **(MCD)**
Zygomorphic (Bilateral symmetry)	Flower can be divided into two equal radial halves by single plane	Pea, Gulmohur, Bean, Cassia. **(Pea GPS)**
Asymmetric (irregular)	No plane divides flower into two similar halves	Canna

Type	Ovary	Example
Hypogynous Flower	Superior ovary	Mustard, China Rose Brinjal
Perigynous Flower	Half inferior ovary	Plum, Peach Rose,
Plum, Peach Rose,	Inferior ovary	Guava and cucumber

A flower may be trimerous, tetramerous or pentamerous when the floral appendages are in multiple of 3, 4 or 5, respectively. Flowers with bracts-reduced leaf found at the base of the pedicel-are called bracteate and those without bracts, ebracteate

Parts of a Flower

Calyx

- Outermost whorl of the flower a
- Members are called sepals. Generally, sepals are green,
- Types: gamosepalous (sepals united), polysepalous (sepals free)

Corolla

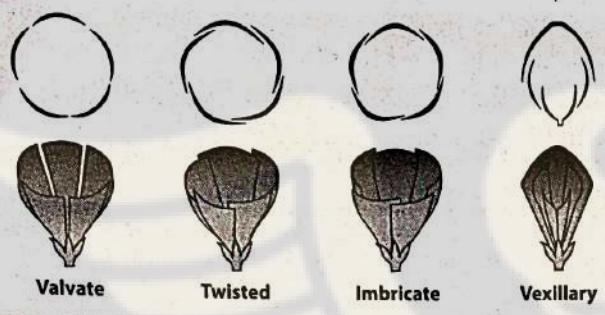
- Members are called petals
- Petals are usually colored to attract insects for pollination
- Types: gamopetalous (petals united), polypetalous (petals free)
- In some flowers like lily, the calyx and corolla are not distinct and are termed as **perianth**

Aestivation

Arrangement of sepals or petal with respect to each other, observed in bud stage

Aestivation	Margin of sepal and Petal	Example
Valvate	Margins not over lap	Calotropis **(Kala Valavate)**
Twisted	Twisted	China Rose, Lady's Finger, Cotton **(Chinese lady ne cotton ka finger twist kiya)**
Imbricate	Margin overlap in irregular manner	Cassia , Gulmohur
Vexillary or papilio-naceous	Largest petal (standard) overlaps the two lateral petals (wings) which in turn overlap two smallest anterior petals (keel)	Pea , Bean **(Pea aur bean dan karo pap dhul jayenge)**

Tg:- @chanpsee_neet



Androecium

- Androecium is composed of stamens
- A sterile stamen is called staminode

Stamen	Feature	Example
Epipetalous	stamens are attached to petals	Brinjal
Epiphyllous	Stamen attached to the perianth	Lily
Monadelphous	Stamens united into one bundle	China rose
Diadelphous	Stamens united into two bundle	Pea
Polyadelphous	Stamens united into more than two bundle	Citrus

There may be a variation in the length of filaments within a flower, as in Salvia and mustard

Gynoecium

- Gynoecium is the female reproductive part of the flower
- Made up of one or more carpels
- 3 parts : stigma, style and ovary
- Fused carpels: syncarpous gynoecium ⟶ mustard and tomato.
- Free carpels: apocarpous gynoecium ⟶ lotus and rose
- Placentation : The arrangement of ovules within the ovary is known as placentation.

Placentation	Feature	Example
Marginal	placenta forms a ridge at ventral suture of the ovary, ovules are borne on this ridge forming two rows	Pea
Axile	Placenta is axial - multilocular ovary	China rose, tomato, lemon
Parietal	Ovules develop on the inner wall of ovary - False septum	Mustard, Argemone
Free central	Ovules are borne on central axis - septa are absent	Dianthus and Primrose
Basal	Placenta at the base of ovary	Sunflower

Fruit

- Fruit is a ripened or mature ovary
- Fruit formed without fertilization ⟶ Parthenocarpic fruit E.g., Banana
- Fruit wall is called ⟶ Pericarp

Type	Pericarp	Example
Dry fruit	Pericarp not divisible into layer	
Fleshy fruit	Pericarp divisible into epicarp, mesocarp and endocarp	**Mango :** Epicarp is thin, Mesocarp is fleshy edible, Endocarp is stony hard **Coconut** : mesocarp is fibrous

In mango and coconut, the fruit is known as a drupe

The Seed

Structure of a Dicotyledonous Seed

Structure	Function
Outermost covering	Seed coat (2 layers : outer testa and the inner tegmen)
Scar on the seed coat	Hilum (funicle attached here)
Micropyle	Water enters during seed germination
Embryo	Consist of an embryonal axis and two cotyledons. two ends of the embryonal axis : radicle and plumule
Endosperm	Food storing tissue , castor (endeospermous seed) NON Endospermous seed : bean, gram and pea

Structure of Monocotyledonous Seed

Structure	Feature
Aleurone layer	Proteinaceous outer covering of endosperm that separates the embryo and endosperm
Embryo	Cotyledon : shield in grass called as scutellum Embryonal axis Plumule : enclosed by coleoptile Radicle : enclosed by coleorhiza
Endosperm	Generally, monocotyledonous seeds are endospermic Exception : Orchid : Non endospermic seed

	Fabaceae	Solanaceae	Liliaceae
Leaves	Alternate, venation reticulate, pinnately compound or simple;	Alternate venation reticulate	Alternate parallel venation
Inflores-cence	Racemose	Solitary, axillary or cymose	Solitary / cymose
Flower	Bisexual, zygomor-phic, Pentamerous	Bisexual, actino-morphic	Bisexual; actino-morphic
Calyx	Gamosepalous; valvate/imbricate aestivation	Valvate aestivation	Perianth : valvate aestivation
Corolla	Vexillary aestivation	Valvate aestivation	
Androecium	Diadelphous	Epipetalous	Epipetalous
Gynoecium	Ovary superior	Ovary superior, axile placentation	Ovary superior axile placentation
Seed	Non-endospermic	Endeospermous seed	Endeospermous seed
Fruit	Simple fruit	Mainly berry	Mainly capsule
Floral formula	% ⚥ $K_{(5)}$ $C_{1,2,(2)}$ $A_{(9),1}$ G_1	⊕ ⚥ $K_{(5)}$ $C_{(5)}$ $\widehat{A_{(5)}}$ G_2	Br ⚥ $\widehat{P_{3+3}}$ A_{3+3} G_3
	Pulses (gram, arhar, sem, moong, soyabean; ed-ible oil (soyabean, groundnut); dye (Indigofera); fibres (sunhemp); fodder (Sesbania, Trifolium), ornamen-tals (lupin, sweet pea); medicine (muliathi)	Tomato, brinjal, potato, chilli, Medi-cine (belladonna, ashwagandha); fumigatory (tobacco); ornamen-tals (petunia).	Tulip, Gloriosa, Aloe, Asparagus, colchi-cine (Colchicum autumnale).

Tg. @chanpsjee_neet

06. Anatomy of Flowering Plants

Tissues

- A tissue is a group of cells having a common origin and usually performing a common function.
- Types: Meristematic and permanent tissues

Meristematic tissue

Meristematic tissue are made up of actively diving cells

Types of meristem (depending on location)

- Apical meristem
  - Root apical meristem (occupies the tip of a root)
  - Shoot apical meristem (occupies the end of stem)
  - Some cells of shoot apical meristem constitute the axillary bud which can form a branch or a flower
- Intercalary meristem
  - Occurs between mature tissues
  - Occur in grasses and regenerate parts removed by the grazing herbivores

Types of meristem (depending on origin)

- Primary meristems
  - Appear early in life of a plant ⟶ form primary plant body
  - Both apical meristems and intercalary meristems are primary meristems
- Secondary meristem
  - Meristem that is not present in early life but appear later than primary meristem is k/a Secondary / lateral meristem
  - E.g. Fascicular vascular cambium, interfascicular cambium and cork-cambium

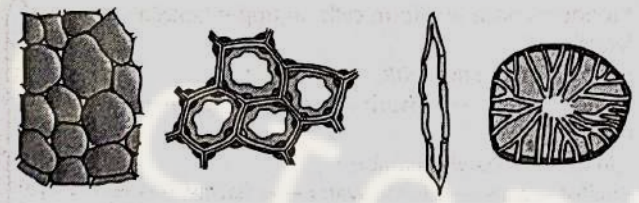
Meristematic cell undergoes differentiation to form permanent cell

Permanent tissue

Simple Tissues

Made up of only one type of cells

Parenchyma	Collenchyma	Sclerenchyma
Shape : spherical, oval, round	oval, spherical or polygonal **Present only in dicots**	They are usually dead and without protoplasts
Cell wall is thin, made up of cellulose	deposition of cellulose, hemicellulose, pectin	**Types : Fibre & Sclerids** **Fibres** are thick walled cells. **Sclerids** are spherical ,oval cells, Found in nuts; guava etc.
Closely packed or small intercellular spaces	Intercellular spaces are absent	
photosynthesis, storage, secretion	provide mechanical support to young stem and petiole of a leaf	Sclerenchyma provides mechanical support to organs



Complex Tissues

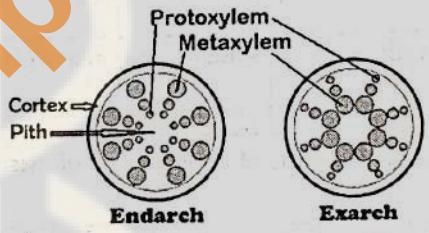
The complex tissues are made of more than one type of cells

Xylem

Tracheids	Vessels	Xylem fibres	Xylem parenchyma
elongated tube like cells, lignified walls	Cylindrical cells, lignified walls	Elongated thick lignified cell	Thin cell wall with Cellulose
dead and are without protoplasm	Dead cells without protoplasm	Dead cells no protoplasm	Living cell
Made of Single cells	Made of many cell	----	---
No perforations	Inter-connected through perforations	No lumen	
Conduct water	Conduct water	Provide support	Store food

The presence of vessels is a characteristic feature of angiosperms, gymnosperms lack vessels.

Stem	Protoxylem lies towards the centre (pith) and the metaxylem lies towards the periphery	Endarch
Roots	Protoxylem lies towards periphery and metaxylem lies towards the centre	Exarch



ProPexoR

Phloem

- Phloem in angiosperms is composed of sieve tube elements, companion cells, phloem parenchyma and phloem fibres.

Sieve tube elements

- Tube-like structures, associated with the companion cells.
- end walls are perforated – sieve plates
- peripheral cytoplasm & large vacuole but lacks a nucleus
- functions of sieve tubes are controlled by companion cells

Companion cells

- specialised parenchymatous cells
- Connected by pit fields to sieve tube cells
- maintain the pressure gradient in the sieve tubes

Phloem parenchyma

- They have dense cytoplasm ⟶ Store food
- Absent in most of the monocotyledons

Phloem fibres (bast fibres)

- Made up of sclerenchymatous cells.
- Absent in primary phloem but found in secondary phloem
- Phloem fibres of jute, flax and hemp are used commercially.

Gymnosperms have albuminous cells and sieve cells. They lack sieve tubes and companion cells

Tg: @shanpsice_neet

The Tissue System

Epidermal Tissue System

The epidermal tissue system forms the outer-most covering of the whole plant body

It consists of epidermal cells, stomata and the epidermal appendages – the Trichomes and hairs.

- **Epidermis**
  - Made up of single layered parenchymatous cell
  - small amount of cytoplasm, large vacuole
  - Covered with a waxy layer called the cuticle, absent in roots
- **Stomata**
  - Made up of Guard cells and subsidiary cell
- **Root hairs :**
  - They are unicellular elongations of the epidermal cells that help absorb water and minerals from the soil
- **Trichomes**
  - Multicellular elongation present on shoot
  - Help in preventing water loss due to transpiration

The Ground Tissue System

All tissues except epidermis and vascular bundles constitute the ground tissue. It consists of simple tissues such as parenchyma, collenchyma and sclerenchyma

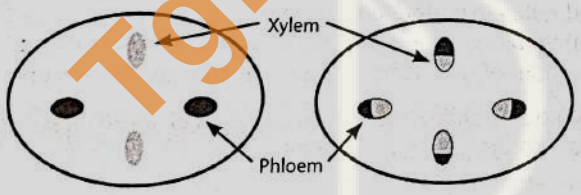
The Vascular Tissue System

Types of vascular bundle (on basis of cambium)

Type	Cambium	Secondary growth	Location
Open vascular bundle	Cambium is present between xylem and phloem	Present	Dicot stem
Closed vascular bundle	Cambium absent	Absent	monocots

Types of vascular bundle (on basis of arrangement of xylem phloem)

Radial vascular bundle	Conjoint vascular bundle
xylem and phloem are arranged in an alternate manner along the different radii	xylem and phloem are jointly situated along the same radius of vascular bundles
Found in roots	in stems and leaves.



Anatomy of Root

Anatomy of Dicot root

Epidermis: outermost layer, compactly arranged parenchymatous cell without intercellular spaces. Unicellular outgrowth ⟶ root hair

Cortex: Thin walled loosely arranged parenchymatous cell

Endodermis: Innermost layer of cortex having single layer of parenchymatous cell, suberin deposition ⟶ **casparian strips**

Pericycle: Inner to endodermis, thick walled parenchymatous cell are present, Initiation of lateral roots and vascular cambium during the secondary growth takes place in these cells

Vascular bundle: 2 – 4 radial vascular bundle

Conjunctive tissue: The parenchymatous cells which lie between the xylem and the phloem are called conjuctive tissue.

Stele: All tissues on the innerside of the endodermis such as pericycle, vascular bundles and pith constitute the stele.

Anatomy of Monocot root

Similar to dicot root, but have : more than six (polyarch) xylem bundles, large pith, secondary growth absent

Anatomy of stem

Anatomy of Dicot stem

Epidermis: have cuticle and trichomes

Hypodermis: made up of collenchyma cell

Cortex: made up of Parenchyma cell

Endodermis: without casparian strip, have **starch sheath**

Pericycle: semilunar patches of sclerenchyma cell

Vascular bundle: conjoint, open vascular bundle, arranged in ring

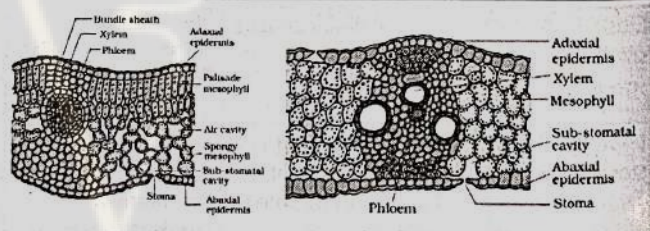
Pith: Large central portion having parenchymatous cell

Anatomy of monocot stem

Differ from dicot stem in having Sclerenchymatous hypodermis, scattered vascular bundles, each surrounded by a sclerenchymatous bundle sheath, conjoint closed vascular bundle; have water containing cavities in xylem

Anatomy of leaf

Dicot leaf	Monocot leaf
Dorsiventral leaf	Isobilateral leaf
Upper (adaxial) surface have less number of stomata	Equal stomata on upper and lower surface
Mesophyll tissue has Palisade and spongy parenchymal cell	The mesophyll is not differentiated into palisade and spongy parenchyma
Reticulate venation	Parallel venation
Bulliform cells absent	Bulliform cells present



Monocots have bulliform cells on upper (adaxial) surface of leaves

- *When water is available*

Bulliform cells ⟶ absorb water ⟶ turgid ⟶ leaf surface exposed.

- *In water stressed condition*

Bulliform cells ⟶ loose water ⟶ flaccid ⟶ leaves curl inwards to minimise water loss.

Tg:- @chanpsiee_neet

Secondary growth

The growth of the roots and stems in length with the help of apical meristem is called the primary growth. Apart from primary growth most dicotyledonous plants exhibit an increase in girth. This increase in girth is called the secondary growth.

Vascular Cambium

Present between xylem and Phloem : Intrafascicular cambium
The cells of medullary rays dedifferentiate to form interfascicular cambium. Thus, a continuous ring of cambium is formed

Activity of the cambial ring

The cambium is generally more active on the inner side than on the outer. As a result, the amount of secondary xylem produced is more than secondary phloem and soon forms a compact mass. The primary and secondary phloem get gradually crushed.
At some places, the cambium forms a narrow band of parenchyma called as secondary medullary rays

Spring wood and autumn wood

Spring wood or early wood	Autumn wood or late wood
In spring cambium is very active	In winter cambium is less active
Produce more xylery elements with wide vessel	Produce xylem is narrow vessel
Spring wood is lighter in color with low density	Autumn wood is darker in color with high density

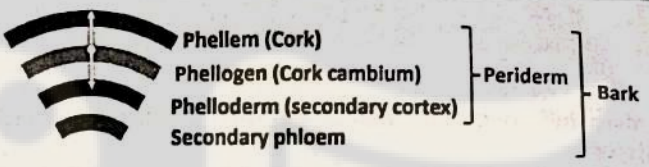
Spring and autumn woods appear as alternate concentric rings, constitute an annual ring.
Annual rings give an estimate of the age of the tree.

Heartwood and sapwood

In old trees, greater part of secondary xylem is dark brown due to deposition of organic compounds like tannins, resins, oils, gums, aromatic substances and essential oils in the central or innermost layers of the stem, this central region constitutes heart wood.

Heart wood	Sap wood
Centrally located with lignified wall	Peripheral in location
Dark in color	Lighter in color
Resistant to microbes	Not resistant to microbes
Do not conduct water	Conduct water

Cork Cambium



- Secondary growth breaks epidermis and cortex.
- Cortical parenchymatous cell de differentiate to form cork cambium or phellogen.
- Outer cells of phellogen forms: cork or phellem
- The cork is impervious to water due to suberin deposition in the cell wall.
- Inner cells of phellogen forms: secondary cortex or phelloderm
- Phellogen + phellem + phelloderm = Periderm
- Periderm + secondary phloem = Bark
- Activity of phellogen ruptures epidermis at certain places forming a lens shaped openings called lenticels.
- Lenticels permit the exchange of gases

Secondary Growth in Roots

- In dicot root, vascular cambium is completely secondary in origin.
- It originates from the tissue located below the phloem bundles and from a portion of ***pericycle tissue***
- Secondary growth also occurs in stems and roots of gymnosperms.
- However, secondary growth does not occur in monocotyledons

Tg: @chanpslee_neet

07. Structural Organisation in Animals

In multicellular animals, a group of similar cells along with intercellular substances performing specific function is called **tissue**.

When two or more organs perform a common function by their physical and/or chemical interaction, they together form **organ system** e.g., digestive system,

There are four types of tissues in animals

(i) Epithelial, (ii) Connective, (iii) Muscular and (iv) Neural.

Epithelial tissues

- Epithelial Tissue provides a covering or a lining for some part of the body. The cells are compactly packed with little intercellular matrix.
- Two types : simple epithelium and compound epithelium

Simple epithelium

- Composed of a single layer of cells

Simple epithelium		
Squamous epithelium	**Cuboidal epithelium**	**Columnar epithelium**
thin layer of flattened cells	single layer of cuble-like cells	a single layer of tall cells.
found in the walls of blood vessels and air sacs of lungs	found in ducts of glands and tubular parts of nephrons in kidneys. PCT of nephron have cuboidal epithelium with microvilli	found in the lining of stomach and intestine
function : form a diffusion boundary	function : secretion and absorption	function : secretion and absorption

Ciliated epithelium

- If the columnar or cuboidal cells bear cilia on their free surface, they are called ciliated epithelium
- Present in the inner surface of hollow organs like bronchioles and fallopian tubes.
- Function: move particles or mucus

Glandular epithelium

- Some of the columnar or cuboidal cells get specialised for secretion and are called glandular epithelium
- Types
  - Isolated glandular cells: goblet cells of alimentary canal
  - Cluster of cells: salivary gland

Glands

- Exocrine glands
  - secrete mucus, saliva, earwax, milk, digestive enzymes etc
  - These products are released through ducts
- Endocrine glands
  - do not have ducts, secret hormone directly into blood

Compound epithelium

- Compound epithelium is made of more than one layer (multi-layered) of cells and thus has a limited role in secretion and absorption
- Location: cover the dry surface of the skin, the moist surface of buccal cavity, pharynx, inner lining of ducts of salivary gland and of pancreatic ducts.
- Function: provide protection against chemical and mechanical stresses.

Three types of cell junctions are found in the epithelium

Tight junctions	help to stop substances from leaking across a tissue.
Adhering junctions	perform cementing to keep neighbouring cells together.
Gap junctions	facilitate the cells to communicate with each other by connecting the cytoplasm of adjoining cells, for rapid transfer of ions, small molecules and sometimes big molecules.

Connective Tissue

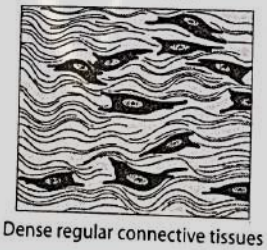
- most abundant tissue
- as name suggest their function is of linking and supporting other tissues/organs of the body.
- In all connective tissues except blood, the cells secrete fibers of structural proteins called collagen or elastin
- connective tissue is made up of cell, fibers and polysaccharide matrix (ground substance)

(i) Loose connective tissue,

- They have loosely arranged fibroblast cells and fibres
- Examples
  - Areolar tissue
    - present beneath the skin
    - contains fibroblasts (cells that produce and secrete fibres),
    - macrophages and mast cells
  - Adipose tissue
    - located mainly beneath the skin
    - function: store fats.

Dense connective tissues

- They have compactly arranged fibroblast cells and fibres
- Types
  - Dense regular connective tissues
    - Orientation of fibres show a regular pattern, collagen fibres are present in rows between many parallel bundles of fibres.
    - Location
      - Tendon: attach skeletal muscles to bones
      - Ligaments: attach one bone to another
  - Dense irregular connective tissues
    - fibroblasts and collagen fibres are oriented differently
    - Location: skin



Dense regular connective tissues

Dense irregular connective tissues

Specialized connective tissues

Cartilage

- Solid and pliable and resists compression
- Composed of chondrocyte cells + collagen fibres + matrix

TG:- @chanpsjee_neet

- Chondrocytes are enclosed in small cavities within the matrix
- Location: tip of nose, outer ear joints, between adjacent bones of the vertebral column, limbs and hands in adults

Bones

- hard and non-pliable ground substance rich in calcium salts and collagen fibres
- provides structural frame to the body
- Osteocytes are present in the spaces called lacunae.
- Bone marrow in some bones is the site of production of blood cells.

Blood

- Fluid connective tissue
- Composed of blood cells (RBC, WBC, Platelets) + Plasma

Muscle Tissue

- Muscle tissue and skeletal, smooth and cardiac muscle is already covered in locomotion and movement chapter
- Communication junctions **(intercalated discs)** in **cardiac muscle** allow the cells to contract as a unit

Neural tissue

- Neurons, the unit of neural system are excitable cells.
- The neuroglial cell protects and support neurons

Organ and organ system

- Tissues organize to form organ which in turn associate to form organ systems .For example, our heart consists of all epithelial, connective, muscular and neural.

Cockroach

Common species	Periplanata americana
Phylum	Arthropoda
Arthropoda	nocturnal omnivores
Body	segmented
Body cover	chitinous exoskeleton
Exoskeleton	exoskeleton has hardened plates called sclerites (tergites dorsally and sternites ventrally), joined by flexible articular membrane (arthrodial membrane).

Head	
Shape	Triangular
Location	lies anteriorly at right angle to the longitudinal body axis formed by the fusion of **six segments**
Antennae	Antennae have sensory receptors that help in monitoring the environment
Mouthparts	consist of a labrum (upper lip), a pair of mandibles, a pair of maxillae and a labium (lower lip)
Tongue	called as hypopharynx lies within the cavity enclosed by the mouthparts
Eyes	Compound

Thorax	
3 parts	prothorax, mesothorax and metathorax
Legs	Pair of legs arises from Prothorax, mesothorax & metathorax

Wings	
Fore wings (tegmina)	arise from mesothorax, opaque dark and leathery
Hind wings	arise from metathorax transparent, membranous and are used in flight
Note : wings do not arise from prothorax	

Abdomen
Abdomen consist of 10 segments

Difference between male and female cockroach

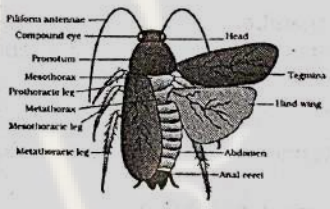
	Male cockroach	Female cockroach
Wings	Extend beyond the tip of abdomen	----
7 the sternum	---------	Boat shaped
Genital Pouch	Bounded by 9th sternum ventrally and 9th and 10th terga dorsally	bounded by 7, 8 9 sterna
	contains dorsal anus, ventral male genital pore and Gonapophysis	Contains spermathecal pore female gonopore, collateral glands
anal styles	Thread like structure called anal styles present in male cockroach	----------
Anal cerci	In both sexes, the 10th segment bears a pair of jointed filamentous structures called anal cerci	

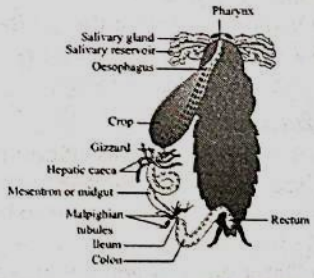
Alimentary canal

Foregut	
Mouth	
Tubular pharynx	
Oesophagus	
Crop	used for storing of food
Gizzard or proventriculus	Have six highly chitinous plate called teeth. Gizzard helps in grinding the food
Entire foregut is lined by cuticle	
Hepatic or gastric caeca	ring of 6-8 tubules is present at the junction of foregut and midgut, it secretes secrete digestive juice

Midgut
Mid gut is also called as Mesenteron

Hindgut
The hindgut is differentiated into ileum, colon and rectum. The rectum opens out through anus.





Circulatory system

- Open type of blood circulation
- Blood is pumped in body cavity (haemocoel)
- Blood (Haemolymph) : colourless plasma and haemocytes RBC
- Heart : located dorsally
  : Present in the form of chamber with ostia on either side

Respiratory System

- Consists of a network of trachea,
- Tracheal tubes open through 10 pairs of small holes called spiracles present on the lateral side of the body.
- Exchange of gases take place at the tracheoles by diffusion.

Tg:- @chemsjee_neet

Excretion

- Performed by Malpighian tubules
- Absorb nitrogenous waste products and convert them into uric acid which is excreted out through the hindgut
- Uricotelic animal
- Fat body, nephrocytes and urecose glands also help in excretion.

Nervous System

- Central nervous system is vental, solid and double
- Three ganglia lie in the thorax, and six in the abdomen
- The nervous system of cockroach is spread throughout the body
- Cut head ⟶ cockroach still alive
- Brain is represented by supra-oesophageal ganglion
- Sensory structures : antennae, eyes, maxillary palps, labial palps, anal cerci, etc.

Eyes

- Compound eyes
- Each eye consists of about 2000 hexagonal ommatidia
- Mosaic vision ⟶ more sensitivity but less resolution

Reproductive system

Male reproductive system

- Testes lie in the 4th - 6th abdominal segments.
- Pathway : Testes ⟶ Seminal vesicle ⟶ ejaculatory duct ⟶ male gonopore ⟶ male Gonapophysis or Phallomere (chitinous structures surrounding the male gonopore)
- Seminal vesicle
  - Store sperm
  - Glue sperm together in the form of bundles called spermatophores
- Mushroom gland
  - Mushroom shaped gland is present in the 6th - 7th abdominal segments which functions as an accessory reproductive gland

Female reproductive system

- Two large ovaries, lying in the 2nd – 6th abdominal segments.
- Each ovary is formed of a group of eight ovarian tubules or ovarioles
- Oviducts of each ovary unite into a single median oviduct (also called vagina)
- Vagina opens into the genital chamber
- A pair of spermatheca is present in the 6th segment also opens into the genital chamber

Fertilization

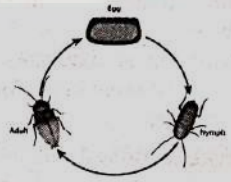
- Bundle of sperms (Spermatophore) are transferred into spermatheca of female
- Fertilized eggs are encased in capsules called oothecae.

Oothecae

- Oothecae is a dark brown capsule glued to a suitable surface
- Each ootheca contains 14 – 16 fertilized eggs
- On an average, females produce 9-10 oothecae

Development

- The development of P. americana is **paurometabolous**, meaning there is development through nymphal stage.
- The nymphs look very much like adults.



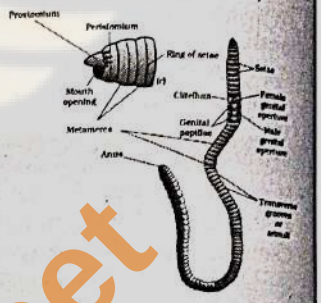
- The nymph grows by moulting about 13 times to reach the adult form.
- Nymph is much similar to adult cockroach but lacks wings and gonads

Earthworm

- The common Indian earthworms are **Pheretima** and **Lumbricus**
- Live in burrows

Morphology

- Divided into more than hundred short segments (metameres)
- Dorsal surface: median mid dorsal line (dorsal blood vessel)
- Ventral surface: genital openings (pores)
- Anterior end consists of the mouth and the prostomium,
- **Prostomium**
  - covering for the mouth
  - open cracks in the soil
  - sensory in function.



- First body segment is called the **peristomium** (buccal segment) Segment 14-16 are covered by dark glandular tissue called clitellum ⟶ function is to produce **cocoon**
- Four pairs of spermathecal apertures - 5th -9th segments
- A single female genital pore - 14th segment
- A pair of male genital pores- 18th segment
- Hair like structure called setae in each body segment except the first, last and **clitellum** ⟶ function is locomotion
- Numerous minute pores called **nephridiopores** open on the surface of the body ⟶ expel out the nitrogenous waste

Anatomy

Body wall

- Outer layer : thin non-cellular cuticle
- Middle layer : epidermis, circular & longitudinal muscle layer
- Inner most : coelomic epithelium
- Epidermis is made up of a single layer of columnar epithelial cells which contain secretory gland cells

Alimentary canal

Runs between first to last segment of the body

- Mouth
- Muscular pharynx
- Esophagus
- Muscular **gizzard** (grinding of soil particle and decaying leaves)
- Stomach (Calciferous glands, present in the stomach, neutralize the humic acid present in humus)
- Intestine (starts at 15th segment)
- A pair of short and conical intestinal caeca project from the intestine on the 26th segment.
- The characteristic feature of the intestine after 26th segment except the last 23rd -25th segments is the presence of internal median fold of dorsal wall called **typhlosole** ⟶ increases absorption area
- Anus

Circulatory System

- Closed circulation
- Haemoglobin is dissolved in blood plasma *(Haemoglobin is NOT contained in RBC)*
- Earthworms lack specialised breathing devices. Respiratory exchange occurs through moist body surface into their blood stream

Excretory Organ

- Excretory organs are coiled tubules called Nephridia (septal, integumentary, pharyngeal nephridia)

Nervous System

- Represented by ventral paired nerve cord.
- Sensory system does not have eyes but does possess light and touch sensitive organs (receptor cells) to distinguish the light

Tg:- @champsjee_bot

intensities and to feel the vibrations in the ground.
- Worms have specialised chemoreceptors (taste receptors) which react to chemical stimuli.

Reproductive System

- Earthworm is hermaphrodite (bisexual), i.e., testes and ovaries are present in the same individual
- Testes ⟶ vas deference ⟶ join the prostatic duct ⟶ opens to the exterior by a pair of male genital pores ⟶ Four pairs of **spermathecae** receive and store spermatozoa during copulation in the form of bundle called spermatophore
- Ovary ⟶ ovarian funnel ⟶ oviduct ⟶ **single** female genital pore

Fertilization

- Two Earthworms exchange spermatophore during mating
- Secretions of clitellum produce cocoon
- Mature sperm and egg cells are deposited in cocoons
- Fertilisation and development occur within the cocoons, thus **fertilization is external**
- After about 3 weeks, each cocoon produces two to twenty baby worms with an average of four.
- Development is **direct**, i.e., there is no larva formed.
- Benefits of earthworm
  - ✓ Friends of farmers
  - ✓ The process of increasing fertility of soil by the earthworms is called **vermicomposting**
  - ✓ They are also used as bait in game fishing

Frogs

- The most common species of frog found in India is **Rana tigrina**.
- Cold blooded or poikilotherms
- Hide them from their enemies (camouflage). This protective coloration is called mimicry
- They deep burrows to protect them from extreme heat and cold. This is known as summer sleep (aestivation) and winter sleep (hibernation) respectively

Morphology

- Skin is smooth and slippery due to the presence of mucus.
- Frog never drinks water but absorb it through the skin.
- Body of a frog is divisible into head and trunk a neck, tail is absent
- Eye: covered by nictating membrane that protects them in water.
- Ear: represented by tympanum, External ear is absent
- Limbs: Hind limbs – 5 digits, fore limbs – 4 digits
- Frogs exhibit sexual **dimorphism**
  - Male frog
    - Have sound producing vocal sacs and
    - Copulatory pad on the first digit of the fore limbs

Anatomy

Alimentary canal

- Alimentary canal is short
- Mouth ⟶ buccal cavity ⟶ pharynx ⟶ stomach ⟶ intestine ⟶ cloaca
- Liver – gall bladder—bile
- Pancreas
- Intestine – villi and microvilli

Respiratory Organ

- In Water ⟶ skin
- On land ⟶ buccal cavity, skin and lungs
- During aestivation and hibernation gaseous exchange takes place through skin.

Circulatory System

- Closed circulation
- Heart : three chambers, two atria and one ventricle
- Heart covering : pericardium.
- Special venous connection
  - Between liver and intestine hepatic portal system
  - Between kidney and lower parts renal portal system
- Haemoglobin is contained in RBC
- RBCs are nucleated

Excretory System

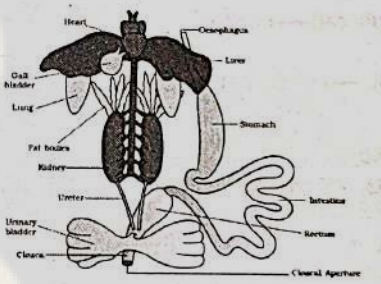
- Consist of kidneys, ureters, cloaca and urinary bladder
- In male frogs, two ureters act as urinogenital duct (carry both sperms and urine) which open into the cloaca.
- Ureter open in cloaca (not in urinary bladder)
- In females, the ureters and oviduct open seperately in the cloaca.
- The frog excretes urea and thus is a ***ureotelic animal***. (Tadpole : excrete ammonia, adult frog : excrete urea)

Nervous System

- Central nervous system (brain and spinal cord),
- Peripheral nervous system (cranial and spinal nerves)
- Autonomic nervous system (sympathetic and parasympathetic).
- There are ten pairs of cranial nerves

Brain

- Forebrain: olfactory lobes, paired cerebral hemispheres and unpaired diencephalon
- Midbrain: pair of optic lobes.
- Hind-brain: cerebellum and medulla oblongata
- The medulla oblongata passes out through the foramen magnum and continues into spinal cord which is enclosed in the vertebral column.



Sense Organs

Organs of touch (sensory papillae), taste (taste buds), Smell (nasal epithelium), vision (eyes) and hearing (tympanum with internal ears)

Endocrine Glands

Prominent endocrine glands eg pituitary, thyroid, parathyroid, thymus etc. found in frog

Reproductive System

Testes

- Sperm produced in testes ⟶ vas efferentia ⟶ Vasa-efferentia opens into the bidder's canal in kidney ⟶ bidder's canal communicates with ureter (carry urine and sperm both)
- Ureter act as urinogenital duct (carry both sperms and urine)

Ovary

- Ovaries are situated near kidneys
- There is no functional connection with kidneys
- Ureter and oviduct opens separately into the cloaca

Fertilization

- Fertilization is external
- Development involves a larval stage called tadpole. Tadpole
- Undergoes metamorphosis to form the adult.

Tg:- @chanpslee_neet

08. Cell: The Unit of Life

What is a cell?

- Cell is the fundamental structural and functional unit of all living organisms.
- **Anton Von Leeuwenhoek** first saw and described a live cell.
- **Robert Brown** discovered the nucleus

Cell theory

- **Matthias Schleiden** stated: all plants are composed of different kinds of cells
- **Theodore Schwann** stated:

1) Animal cell have thin outer layer (Plasma Membrane)
2) Plant cell have cell wall
3) Also proposed Bodies of animals and plants are composed of cells and products of cells.

Schleiden and Schwann together formulated the cell theory. This theory however, did not explain as to how new cells were formed

- **Rudolf Virchow**
- He was the first to explain that cells divide and new cells are formed from pre-existing cells **(Omnis cellula-e cellula)**.
- Rudolf Virchow gave finale shape to Cell theory:

(i) all living organisms are composed of cells & products of cells.
(ii) all cells arise from pre-existing cells

An overview of cell

- Smallest cell ⟶ Mycoplasma bacteria
- Largest single cell ⟶ egg of an ostrich
- Longest cell ⟶ some nerve cells

Size comparison	
Eukaryotic cell	20 um
Bacteria	2 um
PPLO	0.1 um
Viruses	0.2 um

Eukaryotic cell

Organelle		
Single membrane bound	**Double membrane bound**	**Non membrane bound**
Endoplasmic reticulum Golgi body, lysosomes, microbodies, vacuoles,	Nucleus, mitochondria, Plastid	Ribosome, centriole, nucleolus

Prokaryotic cell

Do not contain nucleus and membrane bound organelle

Prokaryotic cells

Prokaryotes are bacteria, blue-green algae, mycoplasma and PPLO (Pleuro Pneumonia Like Organisms)

- **Shapes:**
  bacillus (rod like), coccus (spherical), vibrio (comma shaped) and spirillum (spiral).
- **Cell organelle:**
  Nucleus absent, plasmid (small circular ds DNA outside the genomic DNA), inclusion bodies, mesosomes- inward folding of cell membrane, Cell wall present

Prokaryotic cell

Cell envelope

- Cell envelope of prokaryotic cell is made up of outer glycocalyx, middle cell wall, inner plasma membrane
- Based on differences in cell envelope bacteria are classified a gram positive and gram negative bacteria.

Glycocalyx

- It exists as loose sheath called the slime layer or capsule

Plasma membrane

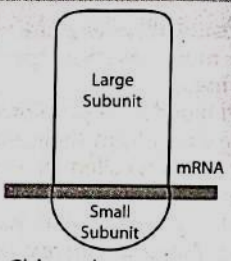
- Selectively permeable in nature
- Mesosomes are the extension of plasma membrane
- Function: cell wall formation, DNA replication, respiration secretion processes,
- Cyanobacteria possess membranous extension of plasma membrane called **chromatophores** which contain pigments.

Extension of cell wall

- Flagella
  - Provide motility to bacteria
  - Composed of three parts – filament, hook and basal body
- Pilli and Fimbriae
  - Fimbriae: help in attachment
  - Pilli: helps in reproduction
  - Fimbriae and Pilli do not play role in motility

Ribosomes

- First observed by George Palade
- It is a non-membrane bound organelle, composed of ribonucleic acid (RNA) and proteins
- Found in both eukaryotic as well as prokaryotic cells



- Found in Cytoplasm, Mitochondria, Chloroplast
- Made up of two subunits hold together by small and large subunit, hold together by magnesium
- Small subunit binds to mRNA, larger subunit synthesize protein
- Prokaryotes have **70S** ribosome made of **50S** and **30S** subunits
- Eukaryotes have **80S** ribosome made of **60S** and **40S** subunits
- Here 'S' (Svedberg's Unit) stands for sedimentation coefficient
- In Prokaryotes, several ribosomes may attach to a single mRNA and form a chain called polyribosomes or **polysome**

Inclusion bodies

- Reserve material in prokaryotic cells is stored in the form of inclusion bodies.
- Not bound by any membrane system and lie free in the cytoplasm, e.g., phosphate, cyanophycean, glycogen granules.
- Gas vacuoles are found in blue green and purple green photosynthetic bacteria

Eukaryotic cells

- Eukaryotes include all the protists, fungi, plants and animals
- Plant cell possess cell walls, plastids and a large central vacuole which are absent in animal cells

Cell Membrane

- Studies on cell membrane are done using red blood cells
- Made up of lipid , proteins , carbohydrate and cholesterol

Tg:- @chanpatee_neet

- **Lipid**
  - Major lipid is phospholipid
  - Hydrophilic, polar head arranged towards the outer side
  - Hydrophobic, non-polar tail arranged toward the inner side
- **Protein**
  - Peripheral proteins lie on the surface of membrane
  - Integral proteins are partially / totally buried in the membrane.
- **Fluid mosaic model**
  - **Singer and Nicolson** proposed fluid mosaic model
  - According to this, the quasi-fluid nature of lipid enables lateral movement of proteins within the overall bilayer. This ability to move within the membrane is measured as its fluidity.
- **Function of plasma membrane**
  - The membrane is selectively permeable in nature
  - Active, passive transport, osmosis covered in transport in plants

Cell Wall

- Cell wall is a non-living rigid structure, found in plants and fungi
- Present on outer side of plasma membrane
- **Primary cell wall**
  - Capable of growth
  - Composed of cellulose, hemicellulose, pectin, proteins
- **Secondary cell wall**
  - Formed on the inner (towards membrane) side of the cell.
  - Made up of lignin, suberin
  - Not capable to grow, seen in mature cell
- **Middle lamina**
  - Composed of calcium pectate
  - Function: glues the neighbouring cells together
- **Plasmodesmata**
  - Connect the cytoplasm of neighbouring cells

Endomembrane System (ER)

- Membranous organelles whose functions are coordinated, together forms endomembrane system
- It includes: endoplasmic reticulum (ER), Golgi complex, lysosomes and vacuoles.

1) Endoplasmic Reticulum (ER)

- ER divides the intracellular space into luminal (inside ER) and extra luminal (cytoplasm) compartments.
- **Rough ER**
  - ER + attached ribosome ⟶ Rough ER ⟶ Protein synthesis
  - Rough ER are continuous with outer membrane of the nucleus.
- **Smooth ER**
  - ER without attached ribosome ⟶ Smooth ER ⟶ Lipid synthesis
  - lipid-like steroidal hormones are synthesised in SER

2) Golgi apparatus

- Discovered by Camillo Golgi
- Made up of sac or cisternae
- The convex cis face (receiving face), located toward nucleus
- The concave trans face is the existing face from which the vesicles leave the Golgi apparatus

- Functions
  - Modification: proteins synthesised by rough ER are modified by Golgi body, synthesize glycoproteins and glycolipids etc
  - Packaging: Modified material is packed in the "vesicle" to be delivered either to the intra-cellular targets or secreted outside

3) Lysosomes

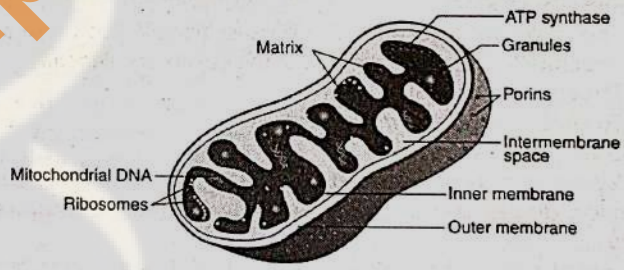
- Lysosomes are membrane bound vesicles
- Formed by Golgi apparatus
- Isolated lysosomal vesicles contain hydrolytic enzymes (hydrolases – lipases, proteases, carbohydrases) optimally active at the acidic pH, capable of digesting carbohydrates, proteins, lipids and nucleic acids

4) Vacuoles

- Vacuole is bound by a single membrane called tonoplast.
- Contains water, sap, excretory product, ions etc
- Ions are transported actively into vacuole hence their concentration is higher in the vacuole than in cytoplasm.
- Amoeba ⟶ contractile vacuole ⟶ osmoregulation and excretion.
- Protist ⟶ food vacuole ⟶ engulf food particles

Mitochondria

- Double membrane-bound structure
- The inner membrane has infoldings ⟶ cristae
- Matrix possesses **ds circular DNA**, ribosomes(70S), RNA
- Semi-autonomous body
- Divide by fission
- Function: aerobic respiration ⟶ ATP ⟶ Powerhouse of cell



Plastids

Found in all plant cells and in euglenoids

Based on type of pigments plastids are classified as :

Chloroplasts	Chromoplasts	Leucoplasts
Contain chlorophyll and carotenoid pigments responsible for trapping light energy essential for photosynthesis	Contains Carotenoid pigments like carotene, xanthophyll ⟶ gives plant a yellow, orange or red colour	Colourless plastids • Amyloplasts store carbohydrates • Elaioplasts store oils • Aleuroplasts store proteins

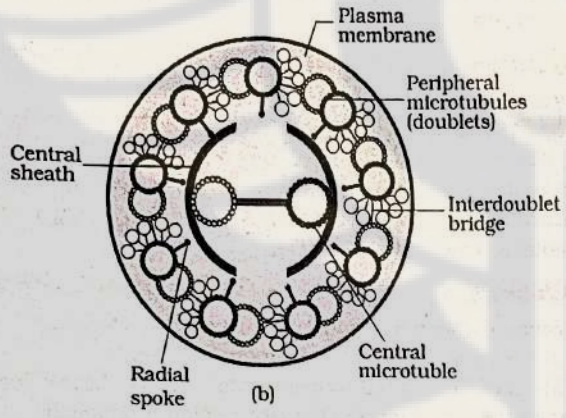
Chloroplast

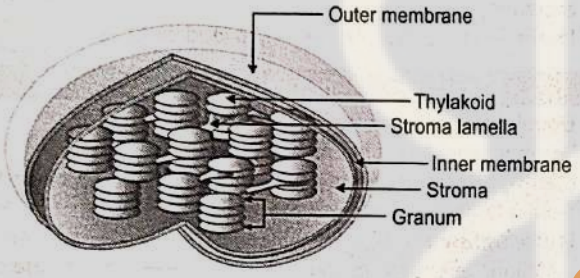
- Found mainly in mesophyll cell
- Double membrane bound structure
- Flattened membranous sacs ⟶ thylakoids
- Thylakoid are arranged in sac ⟶ grana
- Flat tubules that connect thylakoid ⟶ stroma lamellae
- Contains small, double stranded circular DNA, ribosomes (70S)

Tg:- @chanpsjee_neet

Cytoskeleton

- These are Filamentous Proteinaceous structure, types :
  - Microfilament ⟶ pseudopodia formation
  - Intermediate filament ⟶ structural support
  - Microtubules ⟶ support and motility





Cilia and flagella

- The prokaryotic bacteria also possess flagella but these are structurally different from that of the eukaryotic flagella.
- Structure cilium or flagellum
- Covered with plasma membrane
- Core is called axoneme
- Axoneme has nine doublets of radially arranged peripheral microtubules and a pair of centrally located microtubules (9+2)
- Central tubules are connected to peripheral doublets by 9 radial spokes
- Peripheral doublets are also interconnected by linkers
- Both the cilium and flagellum emerge from centriole-like structure called the basal bodies

Centrosome and Centrioles

- Centrosome
  - Centrosome contains two centrioles
  - Centrioles in a centrosome lie perpendicular to each other
- Centriole
  - Made up of 9 peripheral triplets, Central part is called hub
  - Centriole forms centrosome and basal body of cilia / flagella
- Microtubule also forms spindle fibres that give rise to spindle apparatus during cell division in animal cells.

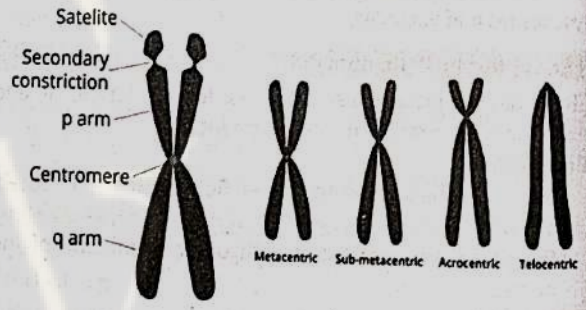
Structure	Microtubule arrangement
Cilia, Flagella	9 + (2)
Centriole	9 + 0
Basal body	9 + 0
Spindle fibre	Random microtubule arrangement

Nucleus

- Nucleus was first described by Robert Brown
- Material of the nucleus given the name chromatin by Fleming
- Double membrane bound structure
- Space between two nuclear membranes : perinuclear space
- Outer membrane remains continuous with the Rough ER
- Nuclear pores allow movement of RNA and protein
- Cell with many nuclei: Muscle cell, tapetal cells
- Cell which lacks nucleus: RBC, Sieve tube cell
- Nuclear matrix or nucleoplasm contains nucleolus & chromatin.
- **Nucleolus**
  - Non membrane bound structure
  - Site of ribosomal RNA synthesis
  - Content of nucleolus is continuous with the rest of nucleoplasm
- **Chromosome**
  - Primary constriction ⟶ centromere
  - ✓ Centromere holds two chromatids of a chromosome
  - ✓ Disc shaped structures on the side of centromere: Kinetochore
  - Non-Staining secondary constriction: Satellite DNA

Types of chromosomes

Chromosome	Location of centromere
Metacentric	middle centromere ⟶ two equal arms of the chromosome.
Sub metacentric	centromere slightly away from the middle ⟶ one shorter & longer arm.
Acrocentric	centromere is close to end ⟶ one extremely short & one long arm



Microbodies: Many membranes bound minute vesicles called microbodies that contain various enzymes, are present in both plant and animal cells.

Tg- @chanpsice_feet

- **G.N. Ramachandran:** triple helical structure of collagen
- **Linus Pauling:** explained α-helix and β-sheet structures
- The concepts and techniques of physics and chemistry are applied to understand biology. This Physicochemical approach to study and understand living organisms is called **'Reductionist Biology'.**

Components of Living organism

How to find organic component of living organism?

Take living tissue ⟶ grind it in trichloroacetic acid ⟶ strain through cotton ⟶ you get filtrate (acid-soluble pool) and retentate or the (acid-insoluble fraction).

Acid soluble pool (Filtrate)	Acid insoluble pool (retentate)
Low Molecular weight (18 – 800 Dalton)	High Molecular weight (Molecular weight More than 10000 Dalton)
Biomicromolecules	Biomacromolecules
Sugar, amino acids, Nucleotides, ions	Carbohydrate, Proteins, Nucleic acid
Represent cytoplasmic composition	Represent cytoplasmic + cell organelle composition

- Weight of lipids do not exceed 800 Da, still considered as macromolecule because lipids form vesicles in acid insoluble pool
- Composition of cell : Water (70%) > Protein (10%) > Carbohydrates (3%) > Lipids (2%)

How to find inorganic components of living organism?

- Destructive method
- Take living tissue (e.g. leaf) ⟶ dry it : water evaporates ⟶ burn it ⟶ carbon compounds gets oxidised to gaseous form ⟶ ash contains inorganic elements (like calcium) ⟶ do analysis

Carbohydrates

Cellulose

- Homopolymer i.e., polysaccharide consisting of only one type of monosaccharide e.g., Glucose
- Found in cell wall of plant, algae
- Cellulose is the most abundant organic polymer on Earth.
- Ruminants can digest cellulose
- Microbes in ruminants have Cellulase enzyme
- Humans can't digest cellulose
- Paper pulp uses cellulose

Starch

- Store house of energy in plant tissues
- Starch forms helical secondary structures.
- Starch can hold iodine (I2) molecules in the helical portion.
- The starch-I2 is blue in colour

Glycogen

- Store house of energy in animal tissues

Inulin

- Polymer of fructose

Chitin

- Chitin is a complex polysaccharide
- Homopolymer of N acetyl Glucosamine
- Forms exoskeleton of insect and fungi

In a polysaccharide chain (say glycogen), the right end is called the reducing end and the left end is called the non-reducing end.

Monosaccharide (contains one sugar unit)

Hexose ($C_6H_{12}O_6$)
- **Glucose** (blood sugar)
- Fructose (Fruit / **sweetest** sugar)
- Galactose (brain sugar)

Oligosaccharide (made up of 2-9 sugar units)

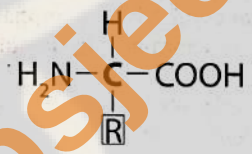
Disacchiarides (contains 2 sugar units)
- Lactose (Milk Sugar) ⟶ Glucose + Galactose
- Sucrose (Table sugar ⟶ Glucose + Fructose
- Maltose ⟶ Glucose + Glucose

Trisaccharide (contains 3 sugar units)
- Raffinose

Polysaccharide (made up of >10 sugar units)
- Cellulose
- Starch
- Inulin
- Glycogen
- Chitin[α]

Amino Acids

- Amino acids are called as α-amino acids.
- They are substituted methane
- Made up of hydrogen, carboxyl group, amino group and a variable group designated as R group.
- Around 20 types of amino acids are found in proteins



R group	Amino acid
Hydrogen	Glycine
Methyl group	Alanine
hydroxy methyl	Serine

- **Nature of amino acids**
  - Acidic amino acids ⟶ Glutamic acid
  - **Basic** amino acid ⟶ **Ly**sine
  - Neutral amino acid ⟶ Valine
  - Aromatic amino acids ⟶ **t**yrosine, **p**henylalanine, **try**ptophan
- **Zwitter ions**
  - A particular property of amino acids is the ionizable nature of $-NH_2$ and –COOH groups. Hence in solutions of different pH, the structure of amino acids changes. Under neutral conditions, the amino acid will exist in its zwitterion form. A zwitterion is a molecule that contains both a positive and a negative charge, ph is called **isoelectric pH**
- **Essential amino acids**
  - Amino acids which are essentially supplied through our diet are called essential amino acids
- **Non-essential amino acids**
  - These are amino acids that body can make

Proteins

- Proteins are polypeptides.
- They are linear chains of amino acids linked by peptide bonds
- Protein is a heteropolymer and not a homopolymer
- **Collagen** is the most abundant protein in animal world
- Ribulose bisphosphate Carboxylase-Oxygenase **(RuBisCO)** is the most abundant protein in the whole of the biosphere.

Protein	Functions
Collagen	Intercellular ground substance
Trypsin	Enzyme
Antibody	Fights infectious agents
Receptor	Sensory reception (smell, taste, hormone, etc.)
GLUT-4	Enables glucose transport into cells

TG: @chanpsiee_neet

Structure of proteins

Primary structure	Amino acids linked with each other to form thread like structure
Secondary structure	The amino acid thread, fold upon itself to form **alpha helix and beta pleated sheet.** In proteins, only right-handed helices are observed
Tertiary structure	Three-dimensional folding pattern where protein thread is folded upon itself (like a hollow woollen ball) with the help of hydrogen and disulphide bond. Tertiary structure is absolutely necessary for the many biological activities of proteins
Quaternary structure	Protein consisting of more than one amino acid chain. e.g., Haemoglobin

Some Secondary Metabolites	
Pigments	Carotenoids, Anthocyanins etc.
Alkaloids	Morphine, Codeine etc.
Terpenoides	Monoterpense, Diterpense etc.
Essential oils	Lemon grass oil etc.
Toxins	Abrin, Ricin
Lectins	**Concanavalin A**
Drugs	Vinblastin, curcumin etc.
Polymeric substances	Rubber, gums, cellulose

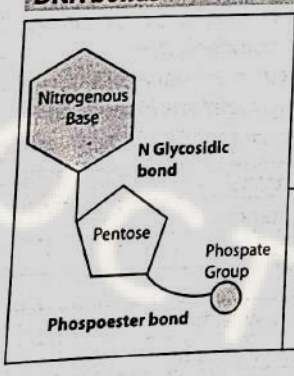
Primary and Secondary Metabolites

- Primary metabolites
  - Primary metabolites are molecules which have identifiable functions and known roles in normal physiological processes,
  - e.g., amino acids, sugars, etc.
- Secondary metabolites
  - Secondary metabolites are molecules produced by plant fungal and microbial cells whose role or functions are not known.

Nucleic Acid

- DNA is a macromolecule
- Nucleic acids exhibit secondary structures
- DNA double helix model was proposed by Watson and Crick
- DNA is a polymer of nucleotide
- Nucleotides is made up of 3 components: monosaccharide, Phosphoric acid or phosphate and heterocyclic compound
- Heterocyclic ring is Purine (Adenine and Guanine) and Pyrimidines (Cytosine, thymine, uracil)
- Each strand appears like a helical staircase
- At each step of ascent, the strand turns 36°.
- One full turn of the helical strand - ten base pairs.
- The pitch = 34Å.
- The rise per base pair = 3.4Å. This
- B-DNA is the term given for the **right-handed DNA helix that is the most common form of DNA**

DNA bonds



Pentose sugar + Nitrogen base: Nucleoside
Nucleoside + Phosphate group: Nucleotide
5' end = free phosphate group
3' end = free OH group

RNA
Sugar: Ribose sugar (- OH group at 2'C)
Uracil in place of thiamine (5 Methyl Uracil)

Nucleoside	Nucleotides
Adenosine	Adenylic acid
Guanosine	Guanylic acid
Thymidine	Thymidylic acid
Uridine	Uridylic acid
Cytidine	Cytidylic acid

Lipids

- Lipids are: fatty acids, glycerol and phospholipids
- Fatty acids
  - A fatty acid has a carboxyl group attached to an R group
  - Palmitic acid has 16 carbons, Arachidonic acid has 20 carbon
- Types
  - Saturated Fatty acids: no double bond
  - Unsaturated fatty acids: have one or more C=C double bonds

Glycerol

- Glycerol is trihydroxy propane
- Many lipids have both glycerol and fatty acids. Here the fatty acids are found esterified with glycerol

Phospholipid

- Phospholipids have phosphorous in them
- E.g., Lecithin: major component of bilayer cell membrane
- Sphingolipid: found in myelin sheath of nervous cells

Bonds in Polymers

Polymer	Monomer	Bonds in monomer
Polysaccharide	Monosaccharide	Glycosidic bonds
Proteins	Amino acids	Peptide Bonds
DNA	Nucleotides	Phospodiester bonds
Lipid	Lipid is not a polymer	

Dynamic State of Body Constituents

- The metabolic pathway includes a series of reactions. The metabolite flow, the rate, and direction at which metabolism takes place are called the **dynamic state of body constituents.**
- All metabolic reactions are catalysed by a set of proteinaceous compounds called **enzymes**.
- Anabolic pathways:
  - Simple structure form complex structure
  - Consumes energy
  - E.g., acetic acid becomes cholesterol
- Catabolic pathway:
  - Complex structure leads to simpler structure
  - Releases energy
  - E.g., Glucose becomes lactic acid in our skeletal muscle

Anabolism means construction & catabolism means destruction

The Living State

- The living state is a non-equilibrium steady-state to be able to perform work.
- The living process is a constant effort to prevent falling into equilibrium and is achieved by energy input. The metabolism provides a mechanism for the production of energy.
- The living state and metabolism are synonymous, without metabolism there cannot exist a living state.
- A living organism works continuously so it cannot afford to reach equilibrium because a system at equilibrium cannot perform the work

Tg: @chanpsiee_neet

Enzymes

- Almost all enzymes are proteins except ribozyme which is a nucleic acid (RNA)
- The Globular tertiary structure enables proteins to function as enzymes.
- An active site of enzyme is a pocket into which substrate fits
- Difference between Enzyme catalysts and inorganic catalysts
  - Inorganic catalysts work efficiently at high temperatures and high pressures, while enzymes get damaged at high temperatures
- Carbonic anhydrase enzyme (found in RBC and Plasma) accelerates the below reaction rate by about 10 million times

$$\underset{\text{Carbon Dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} \xrightleftharpoons{\text{Carbonic anhydrase}} \underset{\text{Carbonic acid}}{H_2CO_3}$$

Mechanism of enzyme action

- Enzyme bring out chemical and physical changes in substrate
- Enzyme substrate complex is a transient state
- In both exothermic and endothermic reaction, the 'S' has to go through a much higher energy state or transition state means substrate needs to be activated by energy called as **activation energy**
- Activation energy is needed in both Endothermic and exothermic reaction
- Role of enzyme in reactions is to decrease activation energy

$$E + S \rightleftharpoons ES \longrightarrow EP \longrightarrow E + P$$

The catalytic cycle of an enzyme action can be described in the following steps:

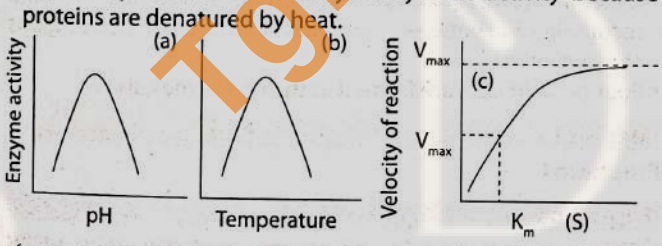
1. First, the substrate binds to the active site of the enzyme,
2. Enzyme alter its shape and fit more tightly around the substrate.
3. Enzyme breaks the chemical bonds of the substrate
4. The enzyme releases the products of the reaction
5. The free enzyme is ready to bind to another molecule of the substrate

Factors Affecting Enzyme Activity

(1) Temperature and pH (2) substrate concentration
(3) binding of specific chemicals

(1) Temperature and Ph

- Each enzyme shows its highest activity at a particular temperature and pH called the optimum temperature and optimum pH
- Activity declines both below and above the optimum value.
- Low temperature ⟶ preserves enzyme in a temporarily inactive state
- High temperature ⟶ destroys enzymatic activity because proteins are denatured by heat.



✓ Km is Substrate conc at which enzyme velocity is half of Vmax

✓ Vmax is the maximum velocity of the reaction for the given concentration of enzyme.

(2) Concentration of Substrate

With the increase in substrate concentration, the velocity of the enzymatic reaction rises at first. The reaction ultimately reaches a maximum velocity (Vmax) which is not exceeded by any further rise in concentration of the substrate

3) Binding of specific chemicals competitive inhibitor

- Closely resembles the substrate
- Competes with substrate for substrate binding site of the enzyme
- Consequently, the substrate cannot bind and as a result, the enzyme action declines
- e.g., inhibition of **succinic dehydrogenase** by malonate which closely resembles the substrate succinate in structure.
- Such competitive inhibitors are often used in the control of bacterial pathogens e.g., Penicillin, for example, is a competitive inhibitor that blocks the active site of an enzyme that many bacteria use to construct their cell wall

Classification and Nomenclature of Enzymes

Enzymes are divided into 6 classes each with 4-13 subclasses and named accordingly by a four-digit number.

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Oxidoreductases/dehydrogenases: Enzymes which catalyse oxidoreduction between two substrates S and S' e.g.,

$$S \text{ reduced} + S' \text{ oxidised} \longrightarrow S \text{ oxidised} + S' \text{ reduced}$$

Transferases: Enzymes catalysing a transfer of a group, G (other than hydrogen) between a pair of substrate S and S' e.g.,

$$S - G + S' \longrightarrow S + S' - G$$

Hydrolases: Enzymes catalysing hydrolysis of ester, ether, peptide, glycosidic, C-C, C-halide or P-N bonds.

Isomerases: Includes all enzymes catalysing inter-conversion of optical, geometric or positional isomers.

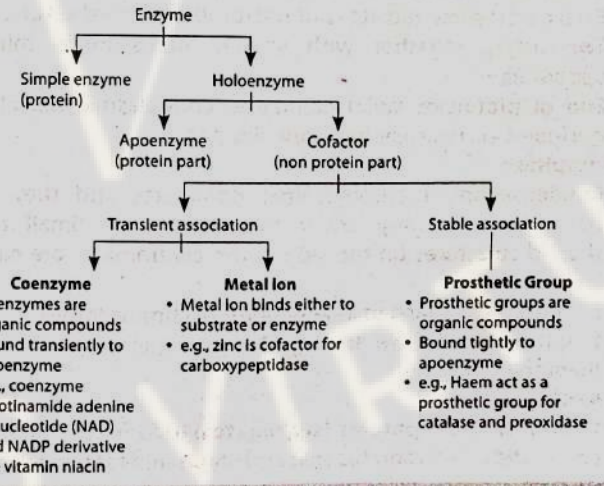
Ligases: Enzymes catalysing the linking together of 2 compounds, e.g., enzymes which catalyse joining of C-O, C-S, C-N, P-O etc. bonds.

Lyases: Enzymes that catalyse removal of groups from substrates by mechanisms other than hydrolysis leaving double bonds

$$\begin{array}{c} X \quad Y \\ | \quad\ \ | \\ C - C \end{array} \longrightarrow X - Y + C = C$$

Co-factors

- Enzymes are composed of one or several polypeptide chains
- However, there are a number of cases in which non-protein constituents called cofactors are bound to the enzyme to make the enzyme catalytically active
- Catalytic activity is lost when the co-factor is removed from the enzyme
- The protein portion of the enzymes is called the apoenzyme
- Three kinds of cofactors may be identified: prosthetic groups, co-enzymes and metal ions.



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10. Cell Cycle And Cell Division

Cell Cycle

- During Cell division DNA replication & cell growth take place.
- Although cell growth (in terms of cytoplasmic increase) is a continuous process, DNA synthesis occurs only during one specific stage in the cell cycle.
- Duration of cell cycle
  - Eukaryotic cell ⟶ 24 hr
  - Yeast ⟶ 90 Min
  - E Coli divides in 20 Min

Phases of Cell Cycle

The cell cycle is divided into two basic phases:

1. Interphase: Duration 23 hr
2. M Phase (Mitosis phase): duration 1 hr

Interphase (Resting phase)

G1 Phase	S (Synthetic) Phase	G2 Phase
Cell is metabolically active, cell grows continuously	• Synthesis of DNA • DNA amount doubles • Chromosome number remains same • Centrioles duplicates	• Cell grows • Protein synthesis

Quiescent stage (G_0)

- Some Cells exit G1 stage, remain metabolically active but no longer proliferate unless called on to do so depending on the requirement of the organism
- Some Cells exit G1 stage, never divides again called permanent cell e.g., Heart cells, Neurons

Mitotic cell division is only seen in diploid somatic cells. Exceptions : male honey bee and plants that can show mitotic divisions in both haploid and diploid cells

M Phase (Mitosis)

- The M Phase starts with the nuclear division (karyokinesis) and usually ends with division of cytoplasm (cytokinesis).
- Since the number of chromosomes in the parent and progeny cells is the same, it is also called as **equational division**
- Karyokinesis involves four stages: Prophase, Metaphase, Anaphase, Telophase

Karyokinesis

Prophase

- Start of Condensation of chromosome
- Centrosome move towards opposite poles of the cell
- Each centrosome radiates out microtubules called **asters**.
- Two asters together with spindle fibres forms mitotic apparatus
- End of prophase: Golgi complexe, endoplasmic reticulum, nucleolus and nuclear envelope disappear

Metaphase

- Condensation of chromosomes completes and they can be observed clearly under the microscope. Small disc-shaped structures on the side of the centromeres are called kinetochores
- Spindle fibers attach to kinetochores of chromosomes.
- Chromosomes move to **equator** and get aligned along metaphase plate.

Anaphase

- Chromosomes **separates (segregates)** to form two daughter chromatids. Centromeres split and chromatids separate.
- Centromere – leading edge, Chromosome arm – trail behind
- Chromatids move to opposite poles.

Telophase

- Chromosomes cluster at opposite spindle poles and their identity is lost as discrete elements.
- Nuclear envelope develops around the chromosome clusters at each pole forming two daughter nuclei.
- Nucleolus, Golgi complex and ER reform.

Cytokinesis

- Cytokinesis is separation of cytoplasm
- **Cytokinesis in animal cell**
  - furrow appear in the plasma membrane which gradually deepens and ultimately joins in centre dividing the cell cytoplasm into two ⟶ **centripetal** (Outer to inner) cytokinesis
- **Cytokinesis in Plant cell**
  - **cell-plate** that represents the middle lamella between the walls of two adjacent cells appear in the centre of the cell and **grows outward** to meet the existing lateral walls ⊠ centrifugal cytokinesis
- In some organisms karyokinesis is not followed by cytokinesis as a result of which multinucleate condition arises leading to the formation of **syncytium** (e.g., liquid endosperm in coconut).

Significance of Mitosis

- A very significant contribution of mitosis is **cell repair**.
- The cells of the upper layer of the epidermis, cells of the lining of the gut, and blood cells are being constantly **replaced**.
- Mitotic divisions in the Meristematic tissues ⟶ result in a continuous **growth** of plants throughout their life.

Meiosis

- Meiosis results in formation of haploid cell (eg gamete)
- Meiosis reduces the chromosome number by half : reductional division
- Meiosis involve two sequential cycles of nuclear and cell division called meiosis I and meiosis II but only a single cycle of DNA replication.
- Meiosis I is initiated after the parental chromosomes have replicated to produce identical sister chromatids at the S phase.
- Meiosis involves pairing of homologous chromosomes and recombination between non-sister chromatids of homologous chromosomes.
- Four haploid cells are formed at the end of meiosis II.

Meiosis I

Prophase I

Leptotene

- Chromosomes compact and become gradually visible under the light microscope

Zygotene

- Homologous chromosomes start pairing k/a : synapsis
- Chromosome synapsis forms synaptonemal complex, visible under electron microscope
- This synaptonemal complex is called bivalent or a tetrad

Zygote matlab pair, zygotene me chromosomes pair banate hai

Tg:- @chanpsiee_neet

Pachytene

- This phase last longer as compared to previous stages
- Tetrad clearly visible
- This stage is characterized by the appearance of **recombination nodules**, the sites at which crossing over occurs between non-sister chromatids of the homologous chromosomes.
- Crossing over
  - exchange of genetic material between two homologous chromosomes takes place
  - an enzyme-mediated process
  - enzyme involved is called recombinase
  - leads to recombination of genetic material
- End of pachytene: chromosome still linked at the sites of crossing over

Diplotene

- Dissolution of the synaptonemal complex
- Homologous chromosomes separate except at the sites of crossovers, these X shapes structure is called as **chiasmata**
- In oocytes of some vertebrates, diplotene can last for months or years.

Diakinesis

- Terminalization of chiasmata
- Nucleolus, nuclear envelope disappears

Metaphase I

- Bivalent chromosomes align on the equatorial plate
- The microtubules from the opposite poles of the spindle attach to the kinetochore of homologous chromosomes.

Anaphase I

- Separation of homologous chromosomes
- Sister chromatids remain associated at their centromeres

Telophase I

- Nuclear membrane and nucleolus reappear
- Cytokinesis follows and the resultant is called as **dyad of cells**

Interkinesis

- The short lived stage between the two meiotic divisions is called interkinesis.
- There is no replication of DNA during interkinesis

Meiosis II

Prophase II

- In contrast to meiosis I, meiosis II resembles a normal mitosis.
- The nuclear membrane disappears
- Chromosomes again become compact.

Metaphase II

- Chromosomes align at the equator
- Microtubules spindle get attached to the kinetochores of sister chromatids.

Anaphase II

- **Splitting of the centromere** of each chromosome (which was holding the sister chromatids together) takes place
- **Sister chromatids separates**

Telophase II

- Two groups of chromosomes once again get enclosed by a nuclear envelope
- Cytokinesis follows, resulting in - tetrad of cells i.e., four haploid daughter cells

Significance of meiosis

- Reduction division
- Increases the genetic variability in the population ⟶ Evolution

Meiosis I	Meiosis II
Synapsis occur	No synapsis
Crossing over occurs	No crossing over
In metaphase I, paired homologous chromosomes line up at equator	In metaphase II, sister chromatids line up at equator
In anaphase I, paired homologous chromosomes separate and move to opposite poles	In anaphase II, sister chromatids separate and move to opposite poles
At the end of meiosis I, 2 haploid cells are formed	At the end of meiosis I, 4 haploid cells are formed

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11. Transport In Plants

Basics

- Transport over **small distance** occurs by **diffusion** and by cytoplasmic streaming supplemented by active transport.
- Transport over **longer distances** proceeds through the vascular system (the xylem and the phloem) and is called **translocation**.
- Xylem Transport: Unidirectional.
- Phloem Transport: Multidirectional

Means of Transport

Property	Simple Diffusion	Facilitated Transprot	Active Transport
Requires special membrane proteins	No	Yes	Yes
Highly selective	No	Yes	Yes
Transport saturates	No	Yes	Yes
Uphill transport	No	No	Yes
Requires ATP energy	No	No	Yes

Diffusion

- It is the only means for gaseous movement
- Smaller substances diffuse faster.
- **Substances soluble in lipids diffuse through the membrane faster.**
- Diffusion is affected by: the gradient of concentration, the permeability of the membrane separating them, temperature and pressure.

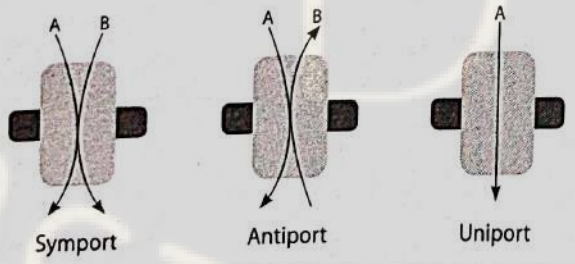
Facilitated Diffusion

- Protein channels are saturable, specific, sensitive to inhibitors
- **Porins** channels are found in outer membranes of the plastids, mitochondria and some bacteria
- **Aquaporin** is a water channel protein, there are 8 different types of aquaporins.

✓ Types of Protein channel

Uniport	It moves molecules across the membrane **independent** of other molecules
Symport	It moves two types of molecules in the **same direction**
Antiport	It moves two types of molecules in the **opposite direction**

Active transport is also k/a 'uphill' transport.
Diffusion whether facilitated or not – take place only along a gradient and do not use energy.



Plant-water Relations

- Transpiration: Loss of water in the form of vapor to the air through evaporation from the leaves
- Water is often the limiting factor for plant growth and productivity

Water Potential

- Pure water has greatest water potential, taken as zero
- Water moves from higher water potential to lower wa potential
- Denoted by Psi or Ψw
- If a pressure greater than atmospheric pressure is applied pure water or a solution, its water potential increases.
- Presence of solute decreases water potential.

Solute Potential

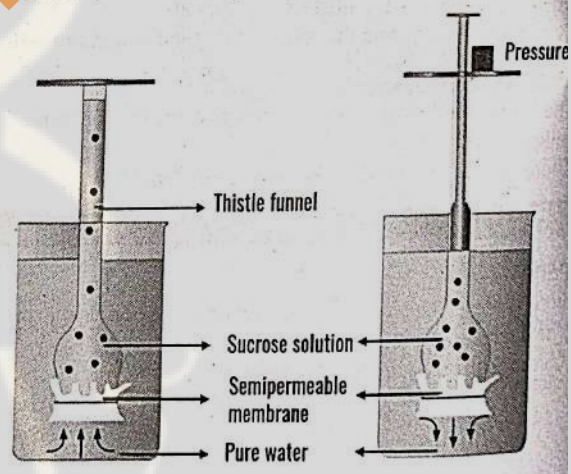
- Magnitude of lowering of water potential due to dissolution a solute is called solute potential or Ψs. Ψs is always negativ
- The more the solute molecules, the lower (more negative) the Ψs

$$\Psi w = \Psi s + \Psi p$$

For a solution at atmospheric pressure :
(water potential) Ψw = (solute potential) Ψs.

Osmosis

- Diffusion of water across selectively permeable membrane called Osmosis
- More the solute concentration, greater will be the pressu required to prevent water from diffusing in.
- Osmotic pressure is equivalent to the osmotic potential, b the sign is opposite.
- Osmotic pressure is the positive pressure applied, wh osmotic potential is negative.



Plant Cell Placed In Variety of Solution

Plant cell in Hypertonic Solution

- Water moves out of the cell
- Plasma membrane shrinks away from cell wall
- The cell is said to be **plasmolysed**

Plant cell in Hypotonic Solution

- Water diffuses into the cell
- Pressure builds up into cell k/a **Turgor pressure**
- The cell is said to be **turgid**

Plant cell in Isotonic Solution

- There is no net flow of water towards the inside or outside, water flows into the cell and out of the cell and are in equilibrium
- The cell is said to be **flaccid**

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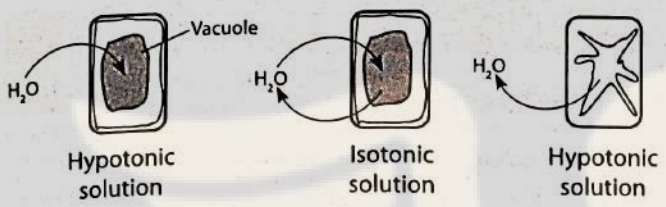


Note:
- Turgor Pressure = Pressure Potential
- Solute Potential = Osmotic Potential = Osmotic Pressure (sign opposite)

Imbibition

- Imbibition is a type of diffusion
- Water is absorbed by solids – colloids – causing them to increase in volume
- Example: Absorption of water by seeds, dry wood.

Long Distance Transport of Water

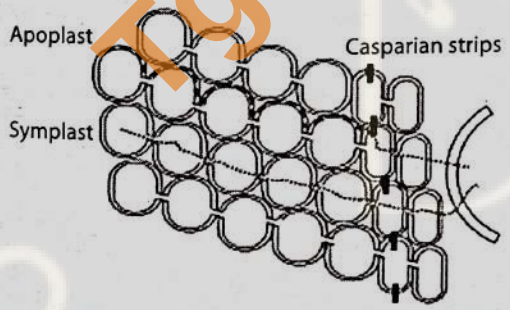
- **Diffusion is a slow process**. It can account for only short distance movement of molecules.
- Water, minerals, and food are generally moved by a **mass or bulk flow system**
- The bulk movement of substances through the conducting or vascular tissues of plants is called **translocation**.

How do Plants Absorb Water?

- Water is absorbed along with mineral solutes, by the root hairs, purely by diffusion.
- Absorbed water move deeper into root layers by two distinct pathways:
  - Apoplast pathway
  - Symplast pathway

Apoplast	Symplast
Movement of water occurs through intercellular spaces, walls of the cells or through xylem	The water travels through the cells, intercellular movement is through Plasmodesmata
Movement is faster & along gradient	Movement is slower & along gradient

✓ Most of the water flow in the roots by ⟶ **apoplast**
- Inner boundary of the cortex, the endodermis, is impervious to water because of a band of suberised matrix called the **casparian strip**.
- The movement of water through the root layers is ultimately **Symplastic** in the endodermis
- Endodermal cells are **control points**, where a plant adjusts the quantity and types of solutes that reach the xylem.



Mycorrhiza

- Mycorrhiza is a symbiotic association of a fungus with a root system.
- Fungus provides minerals and water to the roots
- Roots provide sugars and Nitrogen to the mycorrhizae
- **Pinus** seeds cannot germinate and establish without the presence of mycorrhizae.

Water Movement up a Plant

- Various ions from the soil are actively transported, water follows (its potential gradient) and increases the pressure inside the xylem called **Root pressure**
- Root pressure causes excess water to collects near the tip **(hydathodes)** of grass blades and leaves. Such water loss in its liquid phase is known as **guttation**

Transpiration pull

- Transpiration is the evaporative loss of water by plants, occurs mainly through stomata
- Stomata or pore are surrounded by guard cell
- Function of stomata :
  - Loss of water vapour through transpiration,
  - Exchange of oxygen and carbon dioxide
- Normally stomata are open in the day time and close during the night
- Cause of opening or closing of stomata : change in the turgidity of the guard cells
- Guard cells have
  - Inner thick elastic wall
  - Radially oriented microfibrils
  - Turgid guard cell – stomata open
  - Flaccid guard cells – Stomata closed

Dicots	Monocots
More stomata on lower surface of leaf	Equal stomata on both surfaces of leaf
Dorsiventral leaves	Isobilateral leaves

Transpiration is affected by temperature, light, humidity, wind speed.

Properties of water that helps in transpiration

- **Cohesion** – mutual attraction betⁿ water molecules.
- **Adhesion** – attractⁿ of water molecules to polar surfaces
- **Surface Tension** – water molecules are attracted to each other in the liquid phase more than to water in the gas phase

C4 plants are twice as efficient as C3 plants as C4 plant loses only half as much water as a C3plant for the same amount of CO_2 fixed.

Transport of Mineral Nutrients

- All minerals cannot be passively absorbed by roots, because
  (i) minerals are present in the soil as charged particles (ions) which cannot move across cell membranes and
  (ii) concentration of minerals in the soil is usually lower than the concentration of minerals in the root.
- Minerals enter the root by active absorption
- Mineral ions are frequently remobilised
- Elements most readily mobilised are: (NPK S)
  Nitrogen Phosphorus Potassium and Sulphur
- Elements that are not mobilized are: calcium

Phloem Transport

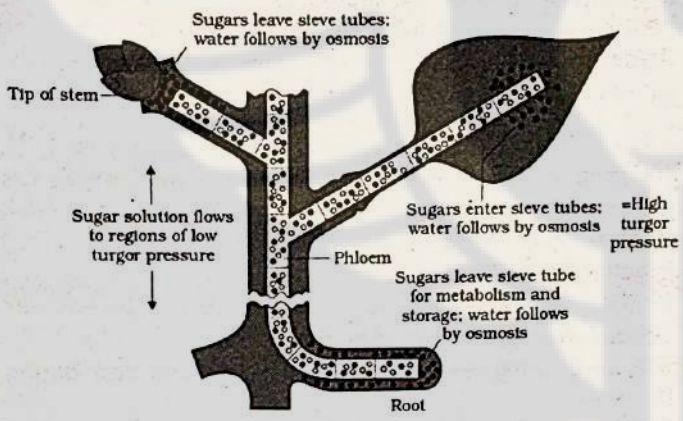
- Phloem sap is mainly water and sucrose,
- Movement in phloem is **bi-directional**

The Pressure Flow or Mass Flow Hypothesis

How sucrose is translocated from source (leaf) to sink (root)?
1) Glucose is synthesized in leaf
2) Glucose is converted to sucrose
3) Sucrose is ***actively*** transported into the companion cells and then into the living phloem (loading)
4) Water in the adjacent xylem moves into the phloem by osmosis.

Tg- @champsjee_neet

5) Osmotic pressure builds into phloem
6) Sucrose moves to sink by pressure flow
7) Sucrose moves out of the phloem sap and into the cells by ***active*** transport (unloading)



Girdling experiment

In this experiment **phloem** layer is removed
↓
Downward movement of food in phloem stops
↓
Sucrose accumulates above girdle ring
↓
Root dies first
↓
This experiment shows that phloem is the tissue responsible for translocation of food; and that transport takes place in one direction, i.e., towards the roots

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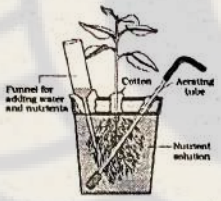
12. Mineral Nutrition

Hydroponics

- Technique of growing plants in a nutrient solution in completely absence of soil is called Hydroponics
- Demonstrated by **Julius von Sac**
- Benefits
  - Identification of essential elements and deficiency symptoms
  - commercial production of tomato, seedless cucumber and lettuce.



Essential Mineral Elements

Criteria for Essentiality

1) The element must be **absolutely necessary** for supporting normal growth and reproduction. In the absence of the element the plants do not complete their life cycle or set the seeds.
2) The requirement of the element must be **specific** and not replaceable by another element.
3) The element must be **directly involved** in the metabolism of the plant.

Total 17 essential elements have been identified

Macronutrients (9)	Micronutrients (8)
Present in plant tissues in large amounts (in excess of mmole Kg^{-1} of dry matter)	Needed in very small amounts (less than 10 mmole Kg^{-1} of dry matter)
Carbon, hydrogen, oxygen, nitrogen, phosphorous, sulphur, potassium, calcium and magnesium	Iron, manganese, copper, molybdenum, zinc, boron, chlorine and nickel

Beneficial elements required by higher plants: Sodium, silicon, cobalt, Selenium

Structural elements of cells	Carbon, Hydrogen, Oxygen, Nitrogen
Energy-related compounds	Magnesium in chlorophyll Phosphorous in ATP
Related Osmotic potential of cell	Potassium

Deficiency Symptoms

The concentration of the essential element below which plant growth is retarded is termed as ***critical concentration***

Deficiency symptoms ***depend on the mobility*** of the element

When leaf becomes old, mineral ions are ***remobilised*** to younger leaf

- Elements mostly readily mobilised
  - Nitrogen (N)
  - Potassium (P)
  - Phosphorous (K)
  - → Deficiency symptoms appear first in the older leaves
- Elements that are not readily mobilised
  - Calcium (Ca)
  - Sulphur (S)
  - → Deficiency symptoms appear first in the younger leaves

Effects on Plants	Defficient Mineral
Necrosis	Ca, Cu, K, Mg
Inhibition of cell division	Mo N K S
Delay in flowering	Mo N S

Toxicity of Micronutrients

Any mineral ion concentration in tissues that reduces the dry weight of tissues by about 10 per cent is considered toxic.

Manganese Toxicity

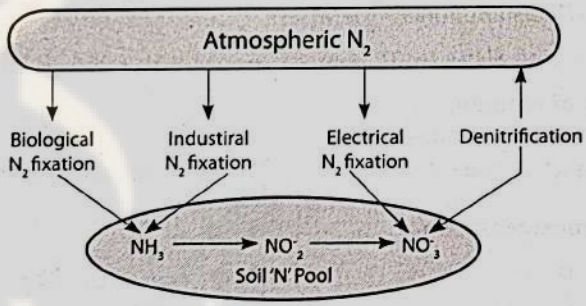
- Inhibits **calcium** translocation in shoot apex
- Competes with **magnesium** for binding to enzyme
- Competes with **magnesium and iron** uptake

Mechanism of Absorption of Elements

- Minerals are absorbed through roots
- First phase, an **initial rapid uptake** of ions into the 'free space' or 'outer space' of cells – the **apoplast**, is passive process
- Second phase is uptake of ions into the 'inner space' of cells – the **symplast**, is active process.The Movement of ions is called flux.

Nitrogen Fixation

- Nitrogen is a constituent of amino acids, proteins, hormones, chlorophylls and vitamins.
- Nitrogen exists as two nitrogen atoms joined by a very strong triple covalent bond (N Ξ N) so plants cannot use this form of nitrogen
- The process of conversion of nitrogen (N_2) to Ammonia is termed as ***nitrogen fixation***.



Biological Nitrogen Fixation

Free living N_2 Fix^n N_2 ⟶ NH_3 (Beijerinckia Azobacker Rhodospirillum)

Nitrification Nitrate is absorbed by platns

NH_3 ⟶ NO_2 (Nitrosomonas Nitrosococcus; Nitrate)

NO^-_2 ⟶ NO^-_3 (Nitrobacter Nitrocystis; Nitrate)

Dentrification N_2 ⟵ NO^-_3 (Pseudomonas Thiobacillus; Nitrate)

Reduction of nitrogen to ammonia by living organisms is called **biological nitrogen fixation**

$$N \equiv N \xrightarrow{\text{Nitrogenase}} NH_3$$

Tg:- @chandsjee_neet

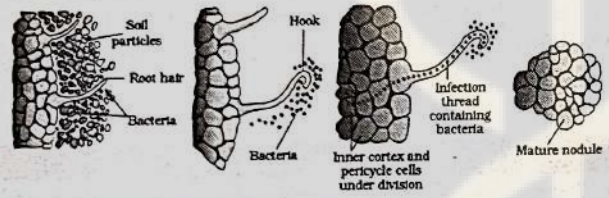
Nitrogen Fixation

- **Bacetria**
  - **Symbolic Association**
    - Rhizobium (Leguminous plants) Frankia (Non leguminous plants eg. Alnus)
  - **Free Living Bacteria**
    - Aerobic
      - Azobacter Azospirillium Beijerinckia
    - Anaerobic
      - Rhodospirillum
- **Cynobacetria**
  - Anabaena is found in leaf of Fern, Azolla
  - Anabaena, Nostoc, Oscillatoria, free living microbes that fix nitrogen in paddy field
  - Cycas have Coralloid root which are associated with N2 fixing cyanobacteria - Nostoc Anabaena

Symbiotic Biological Nitrogen Fixation

Nodule formation

- Rhizobia colonise the surroundings of roots and get attached to epidermal and root hair cells.
- The root - hairs curl - infection thread form - nodule formation in the cortex of the root.
- This establishes a direct vascular connection with the host for exchange of nutrients



Nitrogenase enzyme

- Converts atmospheric nitrogen to ammonia
- Nitrogenase present exclusively in prokaryotes
- Nitrogenase is oxygen sensitive
- **Leghemoglobin** protect nitrogenase from O_2
- Metals in nitrogenase: **Mo and Fe**
- 8 ATP per ammonia

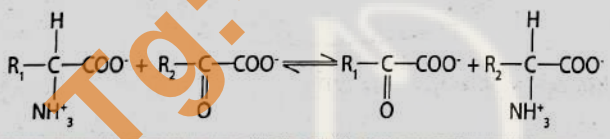
$$N_2 + 8e^- + 8H^+ + 16ATP \longrightarrow 2NH_3 + H_2 + 16ADP + 16P_i$$

Fate of Ammonia

1) Reductive amination

$$\alpha\text{-ketoglutaric acid} + NH^+_4 + NADPH \xrightarrow[\text{Dehydrogenase}]{\text{Glutamate}} \text{Glutamate} + H_2O + NADP$$

2) Transamination



Fate of amino acid

Glutamic acid	Aspartic acid	Amino acid
↓ NH_4	↓ NH_4	
Glutamine	Aspargine	Amide

Transport

- Fixed nitrogen is transported in the form of **Amides** via xylem
- Some plants (e.g., soyabean) transport the fixed nitrogen as ***ureides*** (high nitrogen / carbon ratio)

Ammonification

Decomposition of dead plants and animals to release organic nitrogen in the form of **ammonia** is called ammonification.

Boron	Molybdenum
BO_3^{3-} or $B_4O_7^{2-}$	Molybdate ions (MoO^{2+}_2)
Utilisation of Ca^{2+}, pollen germination, carbohydrate translocation	Component of nitrogenase and nitrate enzyme

Nitrogen	Phosphorous	Pottassium
NO^{3-}	Phospate ion	Pottassium ion
Proteins, nucleic acid, vitamins and hormones	Phosphorylation reactions	Anion cation balance, opening and closing of stomata

Calcium	Magnesium	Iron
Calcium ion	Mg^{2+}	Ferric ion (Fe^{3+})
Synthesis of cell wall, calcium pectate in the middle lamella. Calcium act as second messnger	Activation of RuBisCO, PEP C, Pyruvate dehydro, maintain ribsome structure	Constituent of ferredoxin and cytochromes activates catalase enzyme, Formation of chlorophyll

Manganese	Zinc	Copper
MN^{2+}	Mg^{2+}	Cu^{2+}
Splitting of water	Carboxylase enzyme Synthesis of auxin	Parts of ETS (Complex IV Cyt a3), Plastocyanin

Chlorine	Sulphur
Cl^-	Sulphate SO_4^{2-}
Photolysis of water	Sulphur is present in two amino acids – cysteine and methionine and is the main constituent of several coenzymes, vitamins (thiamine, biotin, Coenzyme A) and ferredoxin

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13. Photosynthesis in Higher Plants

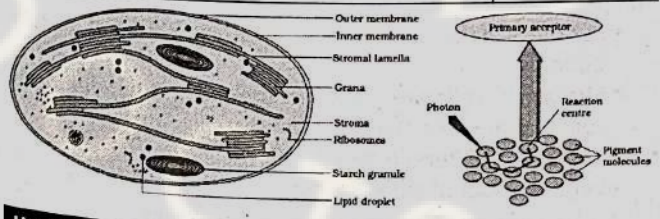
Experiments related to Photosynthesis

Varigated leaf experience	• Photosynthesis occur only in the green parts of the leaves
Von Mohl half leaf experiment	• Used KOH to soak CO_2 • Proved CO_2 is important for photosynthesis
Priestley's Expt	• Photosynthesis restores air quality
Ingenhousz Expt	• Indintified Bubbles are formed around green parts and bubbles are of oxygen and light is imp for photosynthesis
Julius Von Sachs	• Proved Glucose is formed during photosynthesis • Discovered that Glucose is formed in special bodies
T.W Engelmann experiment	• Used green algae **Cladophora** • Gave First **action spectrum**
Cornelius van Niel	• Studied Purple and green bacteria • Proved photosynthesis is a light dependent process • He inferred that the O_2 is evolved by the green plant comes from H_2O, not from carbon dioxide $6CO_2 + 12H_2O \xrightarrow{Light} C_6H_{12}O_6 + 6H_2O + 6O_2$

Where photosynthesis takes place?

- Photosynthesis take place in green parts of the plants
- **Mesophyll cells** in the leaves, have a large number of chloroplasts
- To get optimum light, chloroplasts align themselves *along the walls* of the mesophyll cells,
- Grana are made up of membranous **Thylakoid** also k/a Grana lamellae
- Pigments in thylakoid are organized in to **light harvesting complexes** (LHC / antennae).
- The single chlorophyll a molecule forms the **reaction centre**
- Photosystem = **LHC + Reaction centre Chl a**
- In Photosystem I, reaction centre is Cha a 700
- In Photosystem II, reaction centre is Cha a 680

Division of labour in chloroplast		
Membrane system (Grana, stroma lamellae)	Site of light reactions (photochemical reactions)	Traps Light Synthesize ATP, NADPH
Stroma / Matrix	Site of enzymatic reaction dark reactions (carbon reactions) Light independent reactions	Synthesize sugar



How many types of photopigments involved in Photosynthesis?

Different colors of leaves are d/t presence of various pigments

Main Pigment

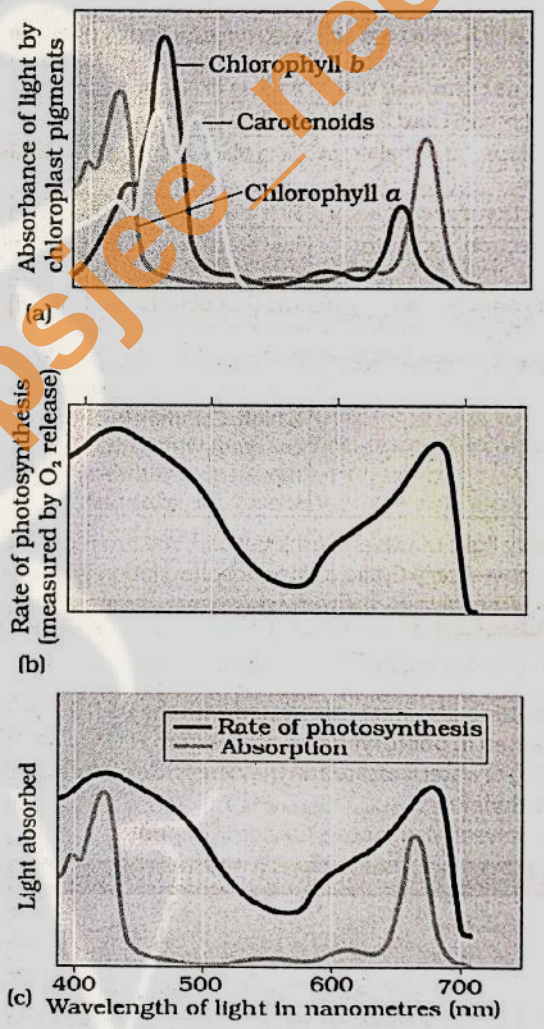
- Chlorophyll a (bright or blue green)

Accessory Pigment

- Chlorophyll b (yellow green)
- Xanthophyll (yellow)
- Carotenoids (yellow-orange)

] Protects Chl a from oxidation

- **Photosynthetically active radiation** (PAR): 400 to 700 nm
- Chief pigment associated with photosynthesis: Chl a
- Max^m absorption by chlorophyll: Blue Red Region
- Maximum Photosynthesis: Blue Red Region
- Accessory pigment enable a wider range of wavelength of incoming light to be utilized for photosynthesis and also protect chlorophyll a from photo-oxidation.
- Absorption spectrum of chlorophyll a and the action spectrum of photosynthesis does ***not*** overlap completely



Electron Transport

1) Light falls on Photosystem II Chl a 680
2) Electrons are excited in response to light of 680nm
3) Electrons are accepted by electron acceptor
4) Electrons are transferred to Electron Transport System (Pq – Cytb6 – PC)
5) Electrons are passed on to PSI
6) Simultaneously, electrons in the reaction centre of PS I are also excited when they receive red light of wavelength 700

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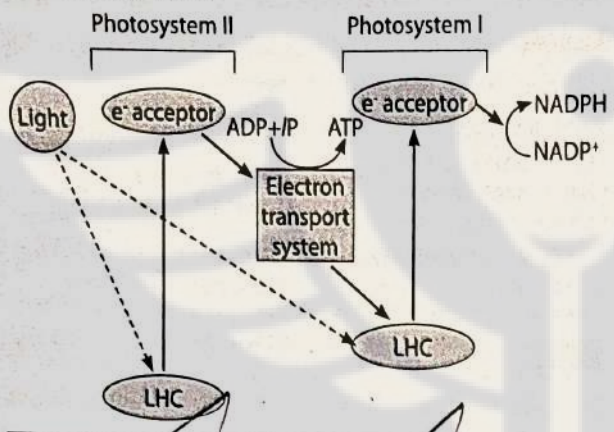
7) Electrons move to NADP+ to form NADPH
8) Movement of electron is **Downhill**, this is k/a **Z scheme** of electron transport



Non cyclic photophosphorylation	Cyclic photophosphorylation
Normal photophosphorylation in which electron expelled by excited photocenter does not returned to it	Photophosphorylation in which electron expelled by photocenter is returned to it after passing through a series of electron carrier
Involve both PSI and PSII	Involve PSI only
Take place at thylakoid lamellae	Take place in stroma lamellae
First electron donor is water	First electron donor is PSI (P700)
Last electron acceptor is NADP	Last electron acceptor is PSI (P700)
Net products are ATP, NADPH, O_2	The product ATP (no NADPH)
Operates in normal condition	Operates when the ratio of NADPH to NADP is too high or light intensity is high. Common in photosynthetic cell types with high ATP needs (e.g. the sugar-synthesizing bundle-sheath cells of plants)

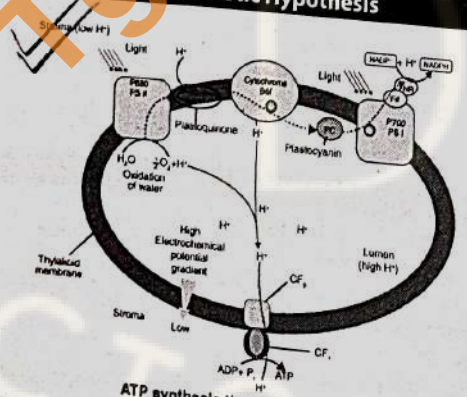
when only light of wavelengths beyond 680 nm is available for excitation ⟶ only Cyclic photophosphorylation will occur

Splitting of Water

$$2H_2O \longrightarrow 4H^+ + O_2 + 4e^-$$

- The splitting of water is associated with the PS II
- O_2 released in photosynthesis comes from H_2O
- Splitting of water is located on the **inner side of the membrane of the thylakoid**
- Ions involved: Manganese, Calcium, Chloride

Chemiosmotic Hypothesis



ATP synthesis through chemiosmosis

Factors responsible for proton gradient

1. Splitting of water accumulates H^+ within the lumen of thylakoids.
2. **Plastoquinone** act as hydrogen pump and pumps H^+ in lumen of thylakoid
3. NADP reductase enzyme is **located on the stroma** side the membrane – forms NADPH, H^+ are removed from stroma to form NADPH

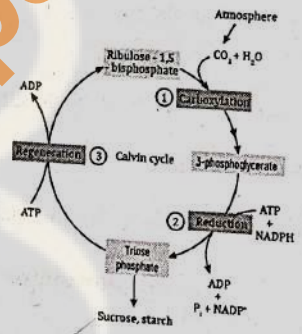
Thus, proton gradient is established between thylakoid lumen and stroma, ATP synthase channel allows diffusion of protons back across the membrane, the released energy is used for formation of ATP

Calvin Cycle

Dark reaction also k/a Biosynthetic phase or Blakeman's reaction, light-independent reaction (hence called Dark reaction) –

Location	Stroma of chloroplast
Steps	Carboxylation -Reduction - Regeneration
Primary acceptor of CO_2	ketose sugar – ribulose bisphosphate (RuBP) (5 C)
Enzyme fixing CO_2	RubisCO
First stable product	3-PGA
End Product	Triose Phosphate G3P
No. of cycles	6 Calvin cycles (6 CO_2) are needed to make 1 glucose molecule
Isotope used	Calvin used ^{14}C isotope – **alga** – chromatography for discovery

Note : Hexose (six-carbon) sugars are not a product of the Calvin cycle, product is Triose Phosphate G3P



In	Out
Six CO_2	One glucose
18 ATP	18 ADP
12 NADPH	12 NAD

Calvin pathway occurs in all photosynthetic plants; it does not matter whether they have C3 or C4 (or any other) pathways

C4 Pathway

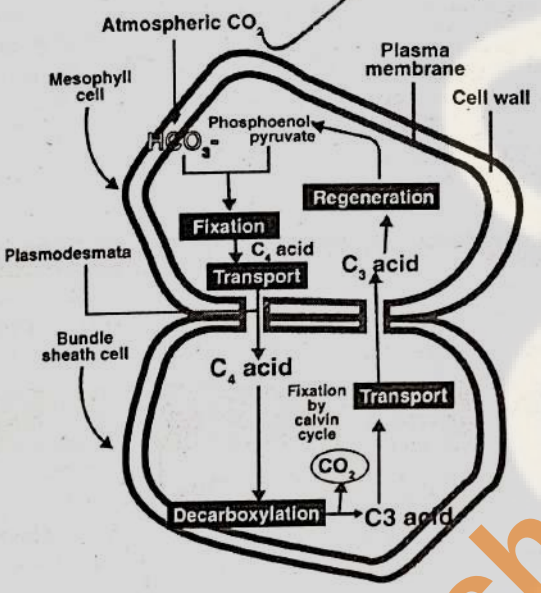
- C4 Cycle - Hatch-Slack pathway
- Seen in plants that are adapted to dry tropical regions
- C4 plants have special leaf anatomy
  - tolerate higher temperatures,
  - show response to high light
  - lack photorespiration
  - have greater productivity
- C4 plants leaves shows Krantz anatomy :
  - Bundle sheath cells form several layers around vascular bundles
  - Mesophyll cells are clustered around the bundle-sheath cells in a ring-like fashion
- Characteristic of Bundle sheath cell
  - large number of chloroplasts (Dimorphic chloroplast)
  - thick walls impervious to gaseous exchange
  - no intercellular spaces
  - C4 Pathway is seen in : maize or sorghum, sugarcane

Tg:-@naapslee_neet

Mesophyll cell	
Primary CO_2 acceptor	Phosphoenol pyruvate
Enzyme	PEP carboxylase
RuBisCO enzyme	mesophyll cells lack RubisCO enzyme
First stable product	Oxaloacetic acid OAA then forms malic acid or aspartic acid which are transported to the bundle sheath cells

Bundle Sheath Cells

C4 acids are broken down to release CO_2 and a 3-carbon molecule
CO_2 released enters the C3 or the Calvin pathway
The bundle sheath cells are rich in enzyme RuBisCO but lack PEP case.



Note :
- Calvin pathway occurs in all the mesophyll cells of the C3 plants but In the C4 plants it does not take place in the mesophyll cells but does so only in the bundle sheath cells.
- Calvin pathway, is common to the C3 and C4 plants.

RuBisCO
- RuBisCO is the most abundant enzyme in the world
- Active site of RuBisCO can bind to both CO_2 and O_2
- RuBisCO has a much greater affinity for CO_2 when $CO_2 : O_2$ is nearly equal
- It is the relative concentration of O_2 and CO_2 that determines which of the two will bind to the enzyme (competitive binding)

Photorespiration	
Seen in	C3 Plants
RuBisCO	RubisCO binds to O2 (instead of CO2)
Products	Phosphoglycerate (3 carbon) & Phospoglycolate (2C)
Condition	High temp, High light intensity,
Organelles involved	Chloroplast, Peroxisome, Mitochondria
Disadvantage	No ATP, No NADPH, No sugar ⟶ Plant growth decreases

- Photorespiration is a wasteful process
- C4 Plants are able to avoid photorespiration and thus have higher yield

Factors affecting Photosynthesis

Blackman's Law of Limiting Factors
If a chemical process is affected by more than one factor, then its rate will be determined by the factor which is nearest to its minimal value

Factors affecting Photosynthesis	
Light	• Light saturation occurs at 10 per cent of the full sunlight. • At higher light intensities, gradually the rate does not show further increase as other factors become limiting
CO_2	• Major limiting factor for photosynthesis. • C4 plants show saturation at about 360 µlL-1 while C3 responds to increased CO_2 concentration and saturation is seen only beyond 450 µlL-1, thus, current availability of CO_2 levels is limiting to the C3 plants. • In Greenhouse, C3 plants respond to higher CO_2 concentration ⟶ rate of photosynthesis increases ⟶ productivity increases ⟶ yield increase seen in tomatoes and bell pepper.
Temp	• C4 plants can tolerate higher Temperature • Dark reactions being enzymatic are temperature controlled • Tropical plants have a higher temperature optimum than the plants adapted to temperate climates.
Water	• Indirect effect • Water loss – stomata close - less CO_2 available for photosynthesis

Note: Oxygen is not a limiting factor

Tg- @chanpsice_neet

14. Respiration In Higher Plants

Introduction

Modes of Nutrition

- **Heterotopic**
  - Animals
    - Obtain food from other animals — ***Carinovres***
    - Obtain food from plants — ***Herbivores***
- **Saprophytes**
  - Fungi
    - Obtain food from dead matter
- **Autotropic**
  - Plants
  - Cynobacteria
    - Prepare their own food

Respiratory Substrates

Definition

C - C bonds are broken down through oxygen to release energy called as **cellular respiration**.

Respiratory substrate

- Carbohydrate
- Proteins
- Fat
- Organic acids

- In respiration, energy is released in a series of slow step-wise reactions controlled by enzymes, and it is trapped as chemical energy in the form of ATP.
- ATP acts as the energy currency of the cell

Do plants breathe?

Plants require O_2

- Plants require O_2 for respiration and they also give out CO_2
- For gaseous exchange,
  - Leaves have stomata
  - Stem and roots have lenticles

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy}$$

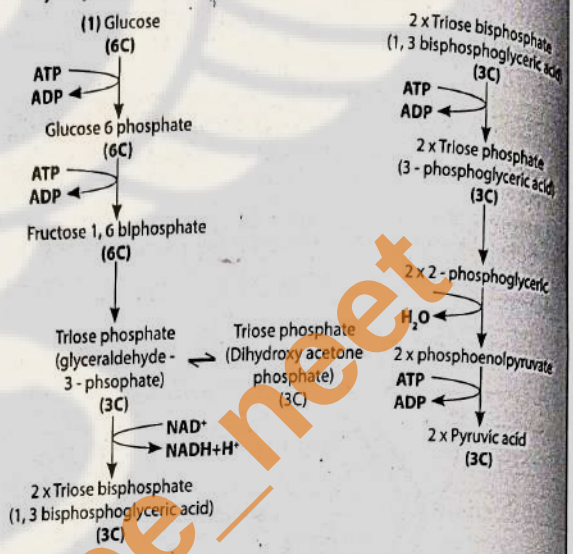
Organism that do not require O_2

Organism that do not need oxygen for growth (ATP) formation

- Anaerobe
  - **Facultative anaerobe**: These organism makes ATP by aerobic respiration if oxygen is present, but is capable of switching to fermenation if oxygen is absent
  - **Obligatory anaerobe**: An organism, such as a bacterium; that can live only in the absence of oxygen

Glycolysis (EMP pathway)

- **All living organisms** retain the enzymatic machinery to partially oxidise glucose without the help of oxygen. This breakdown of glucose to pyruvic acid is called glycolysis.
- Glycolysis is a **partial oxidation** of glucose when glucose is broken to pyruvate
- Sucrose is converted into glucose and fructose by the enzyme, invertase,
- Location: Cytoplasm
- Total ATP formed = 4, ATP used up =2 , Net gain of ATP = 2
- END Product: 2 Pyruvic Acid, 2 NADH, 2 ATP
- Glycolysis takes place in both aerobic and anaerobic organism
- No CO_2 is released during glycolysis.
- Glycolysis do not need O_2
- Oxidation in glycolysis = incomplete oxidation
- Glycolysis do not take place in viruses
- Glycolysis takes place in all living organisms

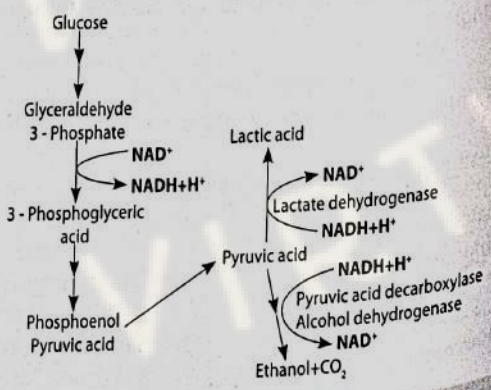


Anaerobic Respiration (Fermentation)

It is incomplete oxidation of glucose, takes place under anaerobic conditions where pyruvic acid is converted to CO_2 and ethanol or lactic acid

	Alcoholic fermentation	Lactic acid fermentation
Condition	Anaerobic condition	Anaerobic condition
Organism / cell involved	Yeast (saccharomyces cerevisiae)	Lactic acid bacteria RBC, white muscle fiber
Substrate	Pyruvate	Pyruvate
Enzymes	Pyruvic acid decarboxylase and alcohol dehydrogenase	lactate dehydrogenase
Product	CO_2 and ethanol	Latch acid (CO_2 is not released here)

- Yeasts dies when concentration of alcohol reaches about 13 %.
- Maximum concentration of alcohol in beverages that are naturally fermented = 13 % to 15 %
- Lactic acid fermentation converts milk to curd
- Both lactic acid and alcoholic fermentation generates NAD



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Aerobic Respiration

Connecting link

- In aerobic respiration pyruvate is transported from the cytoplasm into the mitochondria.
- Pyruvate formed in glycolysis undergoes ***oxidative decarboxylation*** in mitochondrial matrix

$$\text{Pyruvic acid} + CoA + NAD^+ \xrightarrow[\text{Pyruvate dehydrogenase}]{Mg^{2+}} \text{Acetyl CoA} + CO_2 + NADH + H^+$$

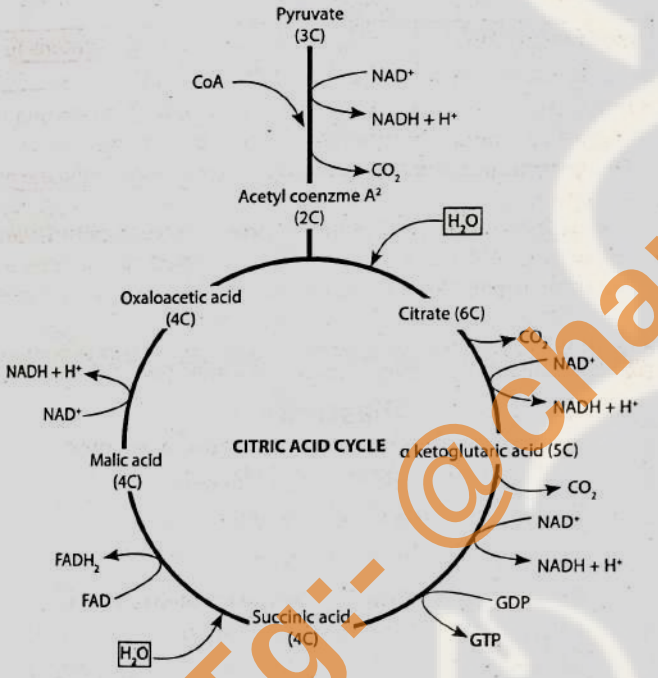
Location	Mitochondrial matrix
Enzyme involved	Pyruvate dehydrogenase
Ion involved	Magnesium
Products	NADH and Acetyl CoA, CO_2

Acetyl CoA enters Kreb cycle

Tricarboxylic Acid Cycle (Kreb cycle)

- Kreb Cycle, Citric acid cycle, TCA Cycle
- Location: Mitochondrial Matrix
- Aerobic
- Number of H_2O required = 2
- Kreb cycle cannot takes place in absence of Oxygen, as oxygen receives electrons and regenerate NAD which is required by Kreb cycle

Output of Kreb cycle : 3 NADH, 2 FADH2, 2 CO_2, 1 GTP



Kreb Cycle		
Cycling	Citrate	
Idea	Isocitrate	One Nadu (NADH) for idea
Of	Oxalosuccinate	
Kool	α ketoglutarate	CO2 before and after kooling Give 1 Nadu (NADH) for Kooling
Superman (is)	Succinyl Co A	Superman gives 1 ATP directly
Successful	Succinate	Its a FADu success
Fantastic	Fumarate	
Mind blowing	Malate	1 Nadu for blowing mind
Ok	Oxaloacetae	

$$\text{Pyruvic acid} + 4NAD^+ + FAD^+ + 2H_2O + ADP + Pi \xrightarrow{\text{Mitochondrial Matrix}} 3CO_2 + 4NADH + 4H^+ + FADH_2 + ATP$$

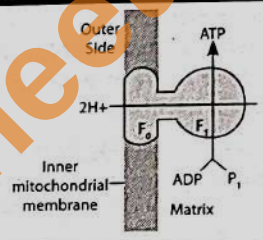
Electron Transport Chain

- Electron Transport Chain release and utilise the energy stored in NADH+H+ and $FADH_2$.
- Location: Inner mitochondrial membrane
- Components: Complex I---- V
- Mobile carrier: Ubiquinone & Cyt C (have 2 copper ions)
- No of ATP: NADH ⟶ 3 ATP, FADH2 ⟶ 2 ATP
- Protons accumulate in: intermembrane space
- Finale electron acceptor: Oxygen
- Energy of oxidation-reduction utilized; it is for this reason this process is k/a oxidative phosphorylation.

Complex I	NADH Dehydrogenase (FMN, FeS)
Complex II	Succinate Dehydrogenase (FAD, Fe S)
Complex III	Cyt bc1 Complex
Complex IV	Cyt C Oxidase **(Copper, cyt and a3)**
Complex V	ATP Synthase (F0, F1)

Complex V

- ATP synthase (complex V)
  - Fo is integral membrane protein
  - F1 is peripheral protein
- 2H+ passes through F0 from the intermembrane space to the matrix down the electrochemical proton gradient to from ATP



The respiratory balance sheet

- Net gain of ATP during aerobic respiration of one molecule of glucose = 38 ATP
- Net gain of ATP during anaerobic respiration(fermentation) = 2 ATP
- Fermentation accounts for only a partial breakdown of glucose whereas in aerobic respiration it is completely degraded to CO_2 and H_2O.

Amphibolic Pathway

Because the respiratory pathway is involved in both anabolism and catabolism, the respiratory pathway as an **amphibolic pathway**

Respiratory substrates

- Carbohydrates are not the only respiratory substrate,
- Other molecules that act as respiratory substrate are:
- Carbohydrate, Proteins, Fat, Organic acids

FAT is made up of fatty acid and Glycerola

Fatty acid —Converted to— Acetyl CoA
Glycerol —Converted to— PGAL
➡ Enters into Kreb Cycle

Proteins —broken to— Amino acid —Converted to— Pyruvate / Acetyl CoA
⬇ Enters into Kreb Cycle

Respiratory Quotient

$$RQ = \frac{\text{Volume of } CO_2 \text{ evolved}}{\text{Volume of } O_2 \text{ consumed}}$$

Substrate	RQ
Carbohydrate	1
Fat	Less than 1
Protein	0.9

RQ of Glucose ($C_6H_{12}O_6$) = 1
RQ of Tripalmitin ($C_{51}H_{98}O_6$) = 0.7

Note:
In living organism respiratory substrates are often more than one; pure proteins or fats are never used as respiratory substrates.

Tg:- @chamsjee_neet

15. Plant Growth & Development

Growth

What is growth and Development?

- Growth is irreversible permanent increase in size of an organ or cell.
- Development is the sum of two processes : Growth and differentiation, it includes all changes that an organism goes through during its life cycle from germination of the seed to senescence

Feature of Plant growth

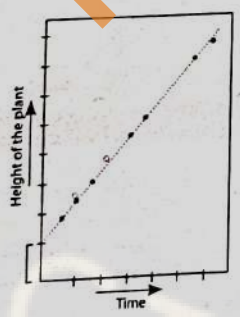
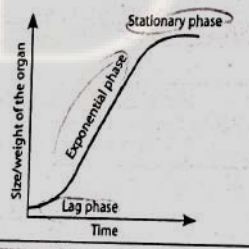
- Growth is unlimited (bcoz of meristematic cells)
- Open form of growth (new cells are always added by meristem)
- Primary growth (root and shoot apical meristem)
- Secondary growth (lat meristem, Dicot Gymnosperm)

Growth is Measurable, measured by parameters such as increase in fresh weight, dry weight, length, area, volume and cell number

Phases of growth

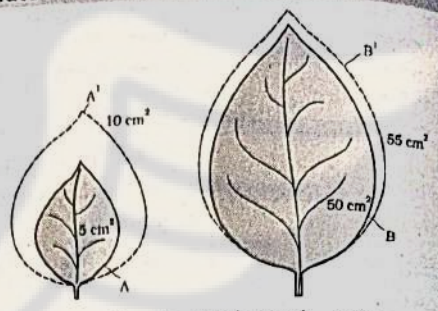
Phase	
Meristematic Phase	Found in root apex and shoot apex Cell in this phase have • Rich protoplasm • Large conspicuous nuclei • Primary cell wall • Plasmodemata connection
Elongation Phase	Cell in this phase have • Vaculation • Secondary cell wall deposition
Maturation Phase	Cell in this phase have • Maximal size thick cell wall

Types of growth

Arithmetic Growth	Geometric Growth
In arithmetic growth, following mitotic cell division, only one daughter cell continues to divide while the other differentiates and matures. Progression is 1, 2, 3, 4 cells	Both the progeny cells following mitotic cell division retain the ability to divide and continue to do so. Progression is seen as 2, 4, 8, 16,...
Seen in roots	Seen in all cells, tissues and organs of a plant
Linear curve 	Sigmoid curve • Lag phase • Exponential phase • Stationary phase 
$L_t = L_0 + rt$	$W_t = W_0 e^{rt}$

✓ **Stages during embryo development showing geometric and arithmetic phases**

Growth rate



- Absolute growth rate = Final growth – initial growth
- Relative growth rate = $\frac{\text{Final growth} - \text{initial growth}}{\text{Initial growth}}$

Differentiation, Dedifferentiation and Redifferentiation

Differentiation	The act of maturation of primary meristem is k/a Differentiation
Dedifferentiation	Differentiated cells regain the capacity of division under certain conditions E.g., parenchyma cells (dedifferentiates) to form interfascicular cambium and cork cambium
Redifferentiation	Dedifferentiated cells again mature to perform specific functions

- Parenchyma cells are made to ***dedifferentiate*** to divide under controlled laboratory conditions during plant tissue culture
- **The growth in plants is open**, i.e., it can be indeterminate or determinate.
- Even **differentiation in plants is open**, because cells/tissues arising out of the same meristem have different structures at maturity. The final structure at maturity of a cell/tissue is also determined by the location of the cell within.

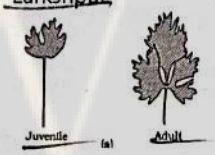
Development

Plasticity

Formation of different kinds of structure in response to environment is k/a Plasticity.

(Eg Heterophylly)

Due to phase of life
- Cotton
- Coriander
- Larkshpur



Due to environment
- Buttercup

Plant Growth Regulators

Growth promoting Activities
- Auxin
- Gibberellins
- Cytokinin

Growth inhibitory Activities
- Ethylene
- Abscisic acid

**Ethylene, could fit either of the groups, but it is largely an inhibitor*

Tg. @chanpsiee_neet

	Auxin	Gibberellic Acid	Cytokinin	Ethylene	Abscisic Acid
Site of synthesis	Root and shoot tips	Seeds	Region of rapid cell division, root, shoot tips, young fruit	Tissues undergoing senescence and ripening fruits.	
	Growth promotor	Growth promotor	Growth promotor	Growth inhibitor	Growth inhibitor
Scientist	Charles Darwin and Francis Darwin (Coleoptile of canary grass), isolated by FW Went	Kurosawa - rice seedling - Bakane diesease	Skug and miller - identified kinetin - Tobacco callus	Cousins - oranges	Independent scientist
	Natural : IAA, IBA Synthetic : 2, 4 D	First gibberellin : Gibberellic acid (GA 3)	Herring fish - Kinetin Corn - Zeatin	Ethephon - liquid form	
Chemical nature	Indole compounds (Indole - 3 - acetic acid, IAA)	Terpenes (gibberellic acid)	Adenine derivatives (N6 - furfurylamino purine)	Gases (ethylene, C2H4)	Carotenoids (abscisic acid)
Effects	• Promote flowering in pineapples • Prevent fruit and leaf drop • Apical dominance, hedge-making • Parthenocarpy in pineapple • 2, 4 D dicot weed killer in garden • Xylem differentiation • Abscission of older leaves • Rooting in stem cutting	• Apple elongation • Malting - alcohol • Delay fruit senescene - help in marketing • Internodal elongation in sugarcane - yield • Conifers seed production • Bolting in beet cabbage • Involved in vernalization of plant	• Overcome apical dominance • Delay of leaf senescence • Adventitious shoot formation • Chloroplast synthesis	• Fruit ripening • Senescence and abscission of plant • Respitory climactic • Internode elongation in rice plant • Flowering in pineapple, mango, cucumber • Germination of seed	• Stress hormone • Inhibits seed germination • Promote seed dormancy • Closure of stomata

Tg:- @chandsjee_neet

Plant hormones showing antagonist (opposite effect)

- Gibberellin (seed germination) X ABA (seed dormancy)
- Auxin (Apical Dominance) X Cytokinin (remove apical dominance)

Plant hormones used in tissue culture

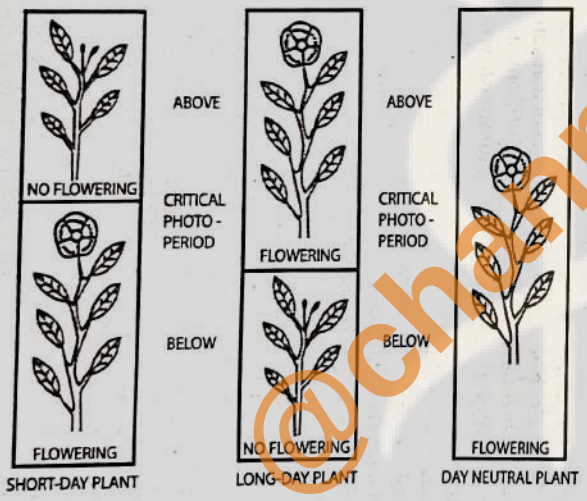
- Auxin: enhance adventitious root formation
- Cytokinin: adventitious shoot formation

Photoperiodism

Plants require a periodic exposure to light to induce flowering, this response is k/a Photoperiodism

Plants that require the exposure to light for a period ***exceeding*** a well-defined critical duration	Plants that require the exposure to light for a period ***less than*** a well-defined critical duration
↓	↓
Long day plants	Short day Plants

- not only the duration of light period but that the duration of **dark** period is also of equal importance
- where there is no such correlation between exposureto light duration and induction of flowering response; such plants are called *day-neutral plants*



Hormonal substance(s) that is responsible for flowering migrates from leaves to shoot apices for inducing flowering.

Vernalisation

- Plants require an ***exposure to low temperature*** to induce flowering, this response is k/a vernalisation.
- Vernalization prevents precocious reproductive development
- Wheat, barley, rye have two kinds of varieties: winter and spring varieties
- Spring variety is planted in spring, it produce grain in summer
  - Winter variety, should be planted in autumn (not in spring), in winter this variety will receive cold treatment (vernalization), it produces grain in summer
  - Winter varieties, if planted in spring would normally fail to flower or produce mature grain within a span of a flowering season
- **Biennial plants:** monocarpic plants that normally flower and die in the second season.
- E.g., Sugar beet, cabbages, carrots
- Subjecting the growing of a biennial plant to a cold treatment stimulates a subsequent photoperiodic flowering response.

Seed Dormancy

Failure of seed to germinate even when external conditions are favourable is k/a Seed Dormancy

➢ *Factors responsible for seed dormancy*

- hard seed coat;
- presence of chemical inhibitors:
  - **abscisic acids**,
  - phenolic acids,
  - para-ascorbic acid;
- Immature embryo

➢ *Methods to overcome seed dormancy*

- Natural Methods
  - Seed coat abrasions caused by microbial action and passage through digestive tract of animals.
- Artificial Methods
  - Breaking seed coat barrier
  - Chilling treatment
  - Application of **gibberellic acid** and nitrates

Tg- @chemistry_neet

16. Digestion And Absorption

Alimentary Canal

Mouth

Teeth

- Embedded in a socket of jaw bone: Thecodont Teeth
- Four types of teeth: Heterodont teeth
- Two sets of teeth – Permanent and temporary (Diphyodont)

Teeth Formula

Milk Teeth

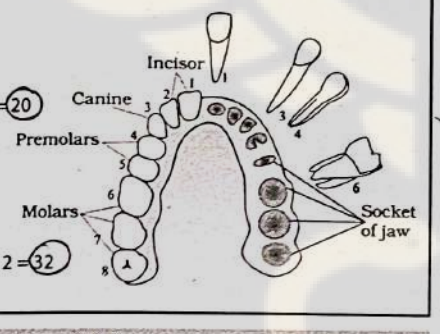
Incisors, I = 2
Canines, C = 1
Molars, M = 2

$\frac{212}{212} \times 2 = 20$

Permanent Teeth

Incisors, I = 2
Canines, C = 1
Premolar, PM = 2
Molars, M = 2

$\frac{2123}{2123} \times 2 = 32$

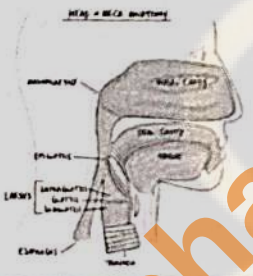


Tongue

- Attached to the floor of the oral cavity by the frenulum
- Upper surface of the tongue has projections called papillae / taste buds

Neck

- Oral cavity leads into short pharynx
- Pharynx is a common passage for food and air
- Pharynx bifurcate as esophagus and larynx / trachea
- A elastic cartilaginous flap called epiglottis prevents the entry of food into the glottis (Larynx)

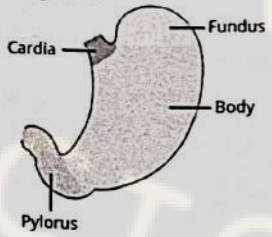


Abdomen

- Oesophagus opens into stomach at gastroesophageal sphincter
- **Stomach has 4 parts**
  - Cardiac portion (oesophagus opens here)
  - Fundus
  - Body (main central region)
  - Pylorus (opens into duodenum)

The opening of the stomach into the duodenum is guarded by the pyloric sphincter

- **Small intestine** has 3 Parts:
  - Duodenum, Jejunum and ileum
  - Ileus opens into caecum (ileocecal valve)
- **Large intestine** has 3 parts:
  - Caecum, colon, rectum



Caecum is a small blind sac which hosts some symbiotic micro-organisms. A narrow finger-like tubular projection, the vermiform appendix which is a vestigial organ, arises from the caecum. The caecum opens into the colon

Layers of alimentary canal (Histology)

Serosa

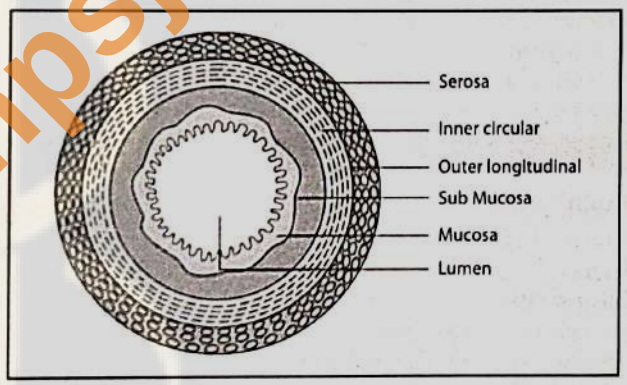
- Outermost layer, made up of a thin mesothelium
- Covered with mucus to avoid friction
- Formed by smooth muscles usually arranged into an inner circular and an outer longitudinal layer
- An oblique muscle layer may be present in stomach

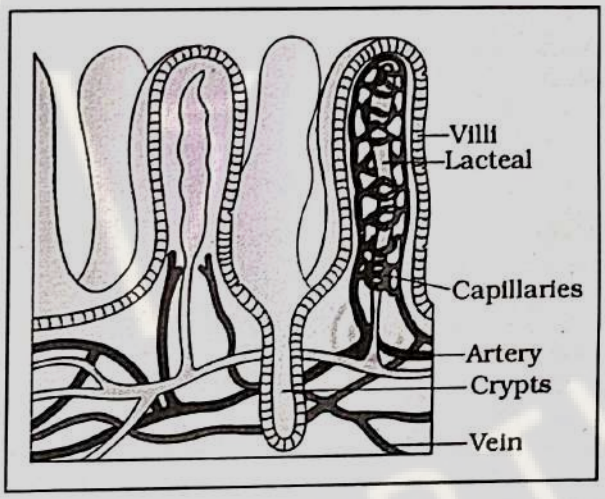
Submucosa

- Formed of loose connective tissues containing nerves
- Submucosa of duodenum → Brunner's gland

Mucosa

- Innermost layer
- Forms irregular folds k/a rugae : Stomach
- Forms finger like projection k/a villi : Small intestine
- Villi is supplied with capillaries and lymph vessel called lacteals
- Intestinal mucosal epithelium has **goblet cells** → secretes mucus
- Mucosa forms gastric gland (in gastric pits) in stomach
- Mucosa forms Crypts (crypts of Lieberkuhn) in between the bases of villi in the intestine
- **Payer's patches** are found in mucosa of **ileum**





Digestive Glands

Salivary glands on mouth

Parotid gland, Submandibular / submaxillary gland and sublingual gland

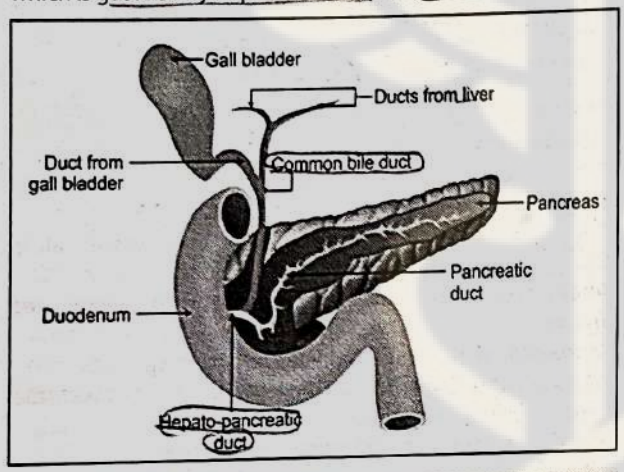
Tg:- @chanpsychi_neet

Liver

- largest gland of the body (weight :1.5 kg)
- Structural and functional units of liver: Hepatic lobule
- Covering of liver: Gilson's capsule

Bile

The bile secreted by the hepatic cells passes through the **hepatic ducts** and is stored and concentrated in a thin muscular sac called the gall bladder. The duct of gall bladder **(cystic duct)** along with the hepatic duct from the liver forms the **common bile duct.** The bile duct and the pancreatic duct open together into the duodenum as the common hepato-pancreatic duct which is guarded by a sphincter called the sphincter of Oddi



Pancreas

- Mixed gland
- Exocrine part ⟶ secretes enzymes
- Endocrine part ⟶ secretes hormone insulin and glucagon.

Digestion of food

Mouth

- Mucus in saliva helps lubricating the masticated food ⟶ Bolus
- Saliva contains
  - Salivary amylase: Starch ⟶ Maltose
  - Lysosome: antibacterial activity
  - Na, K, Cl, HCO3, ph 6.8
- About 30 per cent of starch is hydrolysed here by Salivary amylase enzyme (optimum pH 6.8) into a disaccharide – maltose.

Starch —Salivary amylase (ph 6.8)→ Maltose

Stomach

- Stores food for 4-5 hrs
- Gastric gland secretes
  - Mucus neck cells : secrete mucus
  - Peptic or chief cells : secrete the proenzyme pepsinogen
  - Parietal or oxyntic cells : secrete HCl (ph 1.8) and Intrinsic factor (factor essential for absorption of vitamin B12)
- Bolus mix with gastric juice forms d/t churning movement of stomach ⟶ Chyme

1) Mucus helps in lubrication and protects gastric mucosa

2) Pepsinogen —HCL→ Pepsin ↓ Protein ⟶ Proteose and Peptones

Gastric lipase

3) Rennin found in infant ⟶ digests milk proteins

4) Salivary lipase ⟶ Fat digestion

5) Mucus and bicarbonates present in the gastric juice protects mucosal epithelium from excoriation by the highly concentrated hydrochloric acid.

Pancreas

Trypsinogen	—Enterokinase (Intesitne)→	Trypsin ⟶	Activates Chymotrysionogen, Carboxypeptidase
Proteins, Peptones, Proteoses	—Trypsin/Chymotrypsin, Carboxypeptidase→	Dipeptides	→ Protein digestion, → Carbohydrate digestion, → fat digestion
Polysaccharides (starch)	—Amylase→	Disaccharides	
Fats	—Lipases→	Diglycerides ⟶	Monoglycerides
Nucleic acids	—Nucleases→	Nucleotides ⟶	Nucleosides

Bile

- Bile contains bilirubin and biliverdin, bile salts, cholesterol and phospholipids but no enzymes
- Bile helps in emulsification of fats, i.e., breaking down of the fats into very small micelles.
- Bile also activates lipases; Bile do not contain any enzyme

Small intestine (Duodenum)

- Intestinal mucosa: Goblet cells ⟶ Mucus
- Sub mucosal gland in duodenum: Brunner's Gland ⟶ Mucus

Dipeptides	—Dipeptidases→	Amino acids		
Maltose	—Maltase→	Glucose + Glucose		
Lactose	—Lactase→	Glucose + Galactose		
Sucrose	—Sucrase→	Glucose + Fructose		
Nucleotides	—Nucleotidases→	Nucleosides	—Nucleotidases→	Sugars + Bases
Di and Monoglycerides	—Lipases→	Fatty acids + Glycerol		

Vit B12 is absorbed in ileum

Secretions of intestine is k/a intestinal juice or succus entericus

Large intestine

- No significant digestive activity occurs in the large intestine
- Absorption of water takes place
- Undigested, unabsorbed substances called faeces enters into the caecum, ileo-caecal valve, which prevents the back flow of the faecal matter.

Control of activities of GIT

- **Hormonal control (Gastrin, secretin etc.)**
  - Gastrin (stomach) stimulates secretion of HCL, pepsinogen
  - Secretin (Duodenum) stimulates bicarbonate and water secrtn from pancreas
  - CCK (duodenum) stimulates bile and exocrine pancreas
  - GIP (intestine) inhibits HCL secretion
- **Neural control:**
  - Local neural control (Auerbach's and Meissner' plexus) .
  - CNS control

Physiological calorific values

- Carbohydrate: 4 kcal/gm
- Protein: 4 kcal/gm
- Fat: 9 kcal/gm

Tg:- @champsjee_neet

Absorption of digested products

- Glucose, Amino acid, Chloride ion, Lipids ⟶ Simple diffusion
- Glucose, amino acid, Fructose ⟶ Facilitated transport
- Glucose, amino acid, Na+ ⟶ Active transport
- Water ⟶ absorbed along osmotic gradient
- Vit B12 ⟶ absorbed in ileum

Absorption of Fat

- Bile breaks down fat into micelle (emulsification)
- Pancreatic lipase break fat into fatty acid and glycerol
- Fatty acid and glycerol is absorbed into intestinal mucosa
- Fat globule reformed into mucosa , gets covered with protein k/a Chylomicron
- Chylomicron is transported into the lymph vessels (lacteals) in the villi. These lymph vessels ultimately release the absorbed substances into the blood stream

✓ No absorption of food occurs in esophagus

✓ Maximum absorption of food occurs in the small intestine

Site of absorption

Mouth	Certain drugs coming in contact with the mucosa of mouth and lower side of the tongue are absorbed into the blood capillaries lining them
Stomach	Absorption of water, simple sugars, and alcohol etc.
Small Intestine	Principal organ for absorption of nutrients. Glucose, fructose, fatty acids, glycerol ,amino acids etc are absorpbed
Large Intestine	Absorption of water, some minerals and drugs takes place

Terms

Act of swallowing	Deglutition
The absorbed substances finally reach the tissues which utilize them for their activities	Assimilation
The egestion of faeces to the outside through the anal opening	Defecation
Waves of muscular contraction in Esophagus and intestine	Peristalsis
Muscular movements in stomach	Churning

Disorders of digestive system

Jaundice: The liver is affected; skin and eyes turn yellow due to the deposit of bile pigments.

Vomiting: It is the ejection of stomach contents through the mouth. This reflex action is controlled by the vomit centre in the medulla. A feeling of nausea precedes vomiting.

Diarrhoea: The abnormal frequency of bowel movement and increased liquidity of the faecal discharge is known as diarrhoea.

Constipation: In constipation, the faeces are retained within the colon as the bowel movements occur irregularly.

Indigestion: In this condition, the food is not properly digested leading to a feeling of fullness.

Malnutrition: Protein energy malnutrition

Marasmus	Kwashiorkor
deficiency of proteins and calories	protein deficiency unaccompanied by calorie deficiency.
found in infants less than a year in age	found in children more than one year in age
Found in infants who don't get enough mother's milk: deff of carbohydrate, Protein, Fat	Found in infants who do not get enough protein (normal intake of carbohydrate and fat is present)
impairs growth, thin limbs results, dry wrinkled skin	extensive oedema and swelling of body parts are seen

Tg:- @cranpsjee_neet

17. Breathing and Exchange of Gases

Process of exchange of O_2 from the atmosphere with CO_2 produced by the cells is called breathing, commonly known as respiration

Respiratory organs

Sponges, coelenterates, flatworms, etc	Simple diff body
Earthworm	Moist cuticle
Insect	Tracheal tubes
Fish, Aquatic arthropods and molluscs	Gills (branchial respiration)
Amphibian, Reptiles, birds and mammals	Lungs (pulmonary respiration)
Frog in water	Skin (cutaneous respiration)
Frog on Land	Lung, skin, buccal cavity

Human Respiratory System

Nasal chamber

Pharynx

- Nasal chamber opens into pharynx
- Common passage for food and air.

Larynx

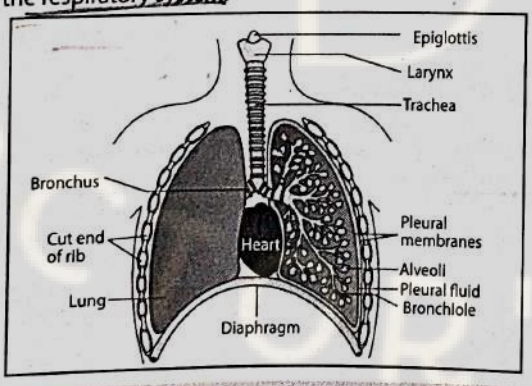
- Pharynx opens into larynx
- Larynx is a cartilaginous box which helps in sound production and hence called the sound box.
- During swallowing, glottis can be covered by a thin elastic cartilaginous flap called epiglottis to prevent the entry of food into the larynx.

Trachea

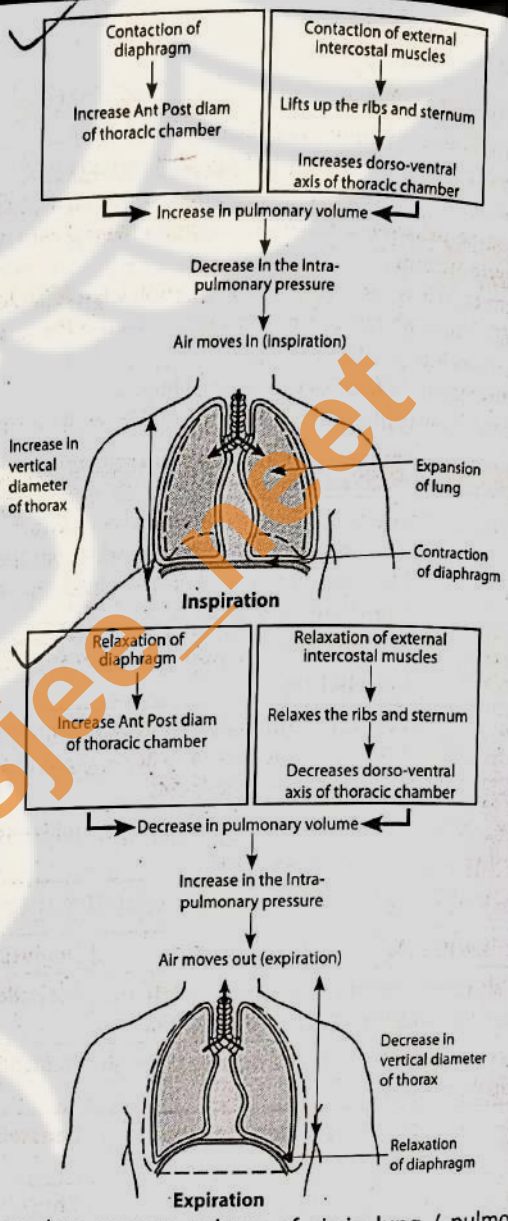
- Larynx continue as trachea
- Trachea is a straight tube which divides at the level of 5th thoracic vertebra into a right and left primary bronchi.
- Each bronchi undergoes repeated divisions to form the secondary and tertiary bronchi and terminal bronchioles
- Terminal bronchiole gives rise to a bag-like structures called alveoli
- Tracheae, primary, secondary and tertiary bronchi, and initial bronchioles are supported by incomplete cartilaginous rings.

Lungs

- Covered by double layered pleura, with pleural fluid between them.
- The part starting with the external nostrils up to the terminal bronchioles constitute the conducting part whereas the alveoli and their ducts form the respiratory or exchange part of the respiratory system.



Mechanism of breathing



Devise used to measure volume of air in lung / pulmonary function test → Spirometer

Respiratory Volumes and Capacities

Tidal Volume (TV)	Volume of air inspired or expired during a normal respiration	500 ml
Inspiratory Reverse Volume (IRV)	Additional volume of air, a person can inspire by a forcible inspiration	3000 ml
Expiratory Reverse Volume (ERV)	Additional volume of air, a person can expire by a forcible expiration	1100 ml
Residual Volume (RV)	Volume of air remaining in the lungs even after a forcible expiration	1200 ml
Inspiratory Capacity (IC)	TV+IRV - Total volume of air a person can inspire after a normal expiration.	
Expiratory Capacity	TV+ERV - Total volume of air a person can expire after a normal inspiration	
Functional Residual Capacity	ERV+RV - Volume of air that will remain in the lungs after a normal expiration	
Vital Capacity	ERV+TV+IRV - The maximum volume of air a person can breathe in after a forced expiration	
Total Lung Capacity	RV, ERV, TV and IRV or RV + Vital Capacity	

Tg:- @chanpsjee_neet

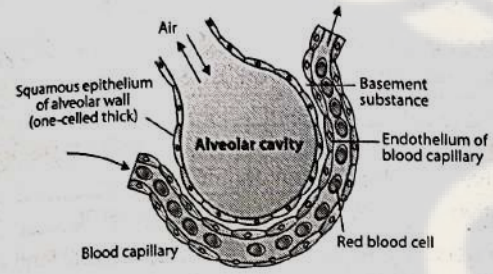
Exchange of gases

- Alveoli are the primary sites of exchange of gases
- CO_2 and O_2 are exchanged at blood and tissue level along conc gradient by simple diffusion

Respitory Gas	Atmo-spheric Air	Alveoli	Blood (Deoxy-genated)	Blood (Oxygen-ated)	Tissues
O_2	159	104	40	95	40
CO_2	0.3	40	45	40	45

- Solubility of CO_2 is 20-25 times higher than that of O_2; the amount of CO_2 that can diffuse through the diffusion membrane is much higher compared to that of O_2

Alveolar diffusion membrane



Made up of three major layers namely,
- thin squamous epithelium of alveoli,
- endothelium of alveolar capillaries and
- basement substance in between them

Transport of gases

O_2 transport

97 % of O_2 ⟶ transported by RBCs in the blood
3 % of O_2 ⟶ transported in dissolved form in plasma

CO2 transport

70 % of CO_2 ⟶ transported as bicarbonate ions
25 % of CO_2 ⟶ transported by RBC
7 % of CO_2 ⟶ transported in dissolved form in plasma

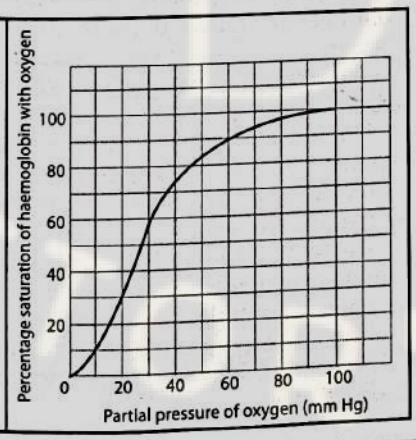
Transport of Oxygen

Haemoglobin

- A red colored iron containing pigment present in the RBCs
- O_2 can bind with Hb in a reversibly form oxyhemoglobin
- Each Hb molecule carries a maximum of four molecules of O_2
- Binding of oxygen with Hb is primarily related to partial pressure of oxygen (pO_2)

A sigmoid curve is obtained when percentage saturation of haemoglobin with O2 is plotted against the pO2 , this curve is called the Oxygen dissociation curve

Right side shift of oxy-Hb curve
Release of O_2 from Hb
1) High CO_2
2) Acidity (↑H^+)
3) 2, 3 DPG
4) Exercise
5) ↑Temperature



In the alveoli	In the tissues
factors favourable for the formation of oxyhaemoglobin present	Factors favourable for dissociation of oxygen from the oxyhaemoglobin present
Shift O_2 – Hb disso curve to right	Shift O_2 – Hb disso curve to left
1) High CO_2 2) Acidity (Increase in H^+) 3) High Temperature	1) Low CO_2 2) decrease in H^+ 3) Low Temperature

Transport of Carbon dioxide

1) ~ 25% of CO_2 is carried by haemoglobin as carbamino- Hb
2) In tissues : High pCO_2 , low pO_2 ⟶ carbamino- Hb forms
3) In alveoli : low pCO_2 , high pO_2 ⟶ CO_2 dissociate from carbamino haemoglobin
4) Inside RBC, bicarbonate ions are formed which diffuse into plasma

$$CO_2 + H_2O \underset{}{\overset{\text{Carbonic anhydrase}}{\rightleftharpoons}} H_2CO_3 \overset{\text{Carbonic anhydrase}}{\rightleftharpoons} HCO_3^- + H^+$$

5) ~ 70% of CO_2 is transported as bicarbonate ions
6) 7 % of CO_2 is transported as dissolved form in plasma
7) 25 % of CO_2 ⟶ transported by RBC
8) CO_2 trapped as bicarbonate at the tissue level, transported to the alveoli, gets released out as CO_2

Note :
- 100 ml oxygenated blood deliver - 5 ml O_2 to tissue
- 100 ml deoxygenated blood deliver - 4 ml O_2 to alveoli
- Carbonic anhydrase is found in RBC and small amount in Plasma

Regulation of respiration

Brain

Medulla ⟶ respiratory rhythm centre is primarily responsible for Respiratory regulation

Pons ⟶ Pneumotaxic centre: can reduce the duration of Inspiration

Chemo sensitive area ⟶ highly sensitive to CO_2 and hydrogen Ions ⟶ sends signal to rhythm centre

Peripheral receptors

Aortic arch and carotid artery receptors ⟶ recognise changes in CO_2 and H+ concentration and send necessary signals to the rhythm centre for remedial actions

The role of oxygen in the regulation of respiratory rhythm is quite insignificant

Disorders of respiratory system

- **Asthma** is a difficulty in breathing causing wheezing due to inflammation of bronchi and bronchioles
- **Emphysema** is a chronic disorder in which alveolar walls gets damaged due to which respiratory surface is decreased. One of the major causes of this is **cigarette smoking**. α-1-antitrypsin used to treat emphysema.
- **Occupational Respiratory Disorders:** In certain industries, especially those involving grinding or stone-breaking, inhalation of particles can give rise to inflammation leading to fibrosis

Tg - @champsjee_neet

18. Body Fluids And Circulation

Blood is the most commonly used body fluid by most of the higher organisms for transport of nutrients and gases

Blood

Blood is a special connective tissue consisting of a fluid matrix, plasma, and formed elements

Plasma (55% of blood)

- Pale yellow (straw color) fluid constitutes 55% of blood
- Plasma is made up of
  1) 90% Water,
  2) 8% Protein
     - Fibrinogen : blood coagulation
     - Albumin : osmotic balance
     - Globulin : defence mechanism
  3) 2% Na^+, Ca^{++}, Mg^{++}, HCO^3-, Cl-, Glucose, amino acids, lipids, clotting factors etc

* Blood = Plasma + WBC + RBC + Platelets
* Plasma = Blood - cellular component
* Serum = Plasma - clotting factors
* Lymph = Plasma + Lymphocytes

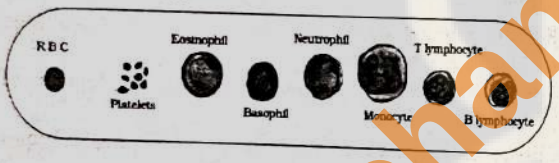
Serum = Plasma - Clotting factors

Formed Elements (45% of blood)

- **Erythrocytes (RBC)**
- 5 millions of RBCs mm-3 of blood
- formed in the red bone marrow in the adults
- devoid of nucleus, contains haemoglobin
- 12-16 gms of haemoglobin in every 100 ml of blood
- life span : 120 days
- destroyed in : spleen (graveyard of RBCs)

Leucocytes (WBC)

Colourless due to the lack of haemoglobin.
6000 mm-3 of blood



Types

- **Granulocyte**
  - **Neutrophils**
    - ✓ Most abundant cells (60%)
    - ✓ Shows Phagocytosis
  - **Eosinophil**
    - ✓ Resist parasitic infection, involve in allergic reaction
  - **Basophils**
    - ✓ Least abundant (1%)
    - ✓ Secrete histamine, serotonin, heparin, etc.
- **Agranulocytes**
  - **lymphocytes**
    - ✓ T lymphocyte : involve in cell mediated immunity
    - ✓ B lymphocyte : Antibody mediated immune response
  - **Monocytes**
    - ✓ Shows phagocytosis

MoNa - Monocytes and Neutrophils shows phagocytosis

Platelets (Thrombocyte)

- 300000 mm3
- Release a variety of substances most of which are involved in the coagulation or clotting of blood
- Reduction in platelets ⟶ excessive loss of blood from the body

Blood Groups

ABO grouping

Blood Group	Antigens on RBCs	Antibodies in Plasma	Donor's Group
A	A	anti-B	A, O
B	B	anti-A	B, O
AB	A, B	nil	AB, A, B, O
O	nil	anti-A, B	O

- Universal blood donor: Blood group O
- Universal acceptor of blood: Blood group **AB**

Rh grouping

Individual with Rh antigen on the surface of RBC ⟶ Rh positive

Blood Group	Rh antigen	Anti Rh antibody
Rh positive	Rh antigen on RBC	absent
Rh negative	RBC lacks Rh antigen	absent

An Rh-ve person, if exposed to Rh+ve blood, will form specific antibodies against the Rh antigens.

Rh incompatibility

Observed between the Rh-ve blood of a pregnant mother with Rh+ve blood of the foetus

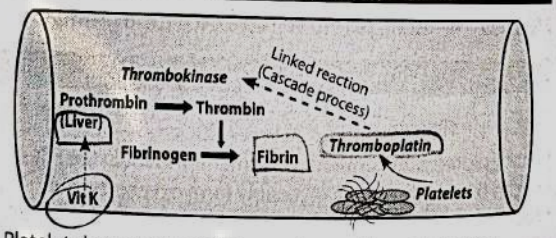
First pregnancy

- During delivery maternal blood may get exposed to Rh+ive blood from foetus ⟶ Mother develops Rh antibodies

Second pregnancy

- Rh antibodies from the mother (Rh-ve) can leak into the blood of the foetus (Rh+ve) and destroy the foetal RBCs ⟶ severe anaemia ⟶ jaundice ⟶ this condition is k/a **erythroblastosis foetalis.**

Coagulation of Blood



- Platelets in response to injury releases thromboplastin
- Calcium ions play a very important role in clotting.

Lymph (tissue fluid)

- As the blood passes through the capillaries in tissues, some water along with many small water soluble substances move out into the spaces between the cells of tissues leaving the larger proteins and most of the formed elements in the blood vessels. This fluid released out is called the **interstitial fluid or tissue fluid**
- It has the same mineral distribution as that in plasma
- Exchange of nutrients, gases, etc., between the blood and the cells always occur through this fluid
- An elaborate network of vessels called the lymphatic system collects this fluid and drains it back to the major veins. The fluid present in the lymphatic system is called the **lymph.**
- Lymph is a colorless fluid containing specialized lymphocytes which are responsible for the immune responses of the body
- Fats are absorbed through lymph in the lacteals present in the intestinal villi.

(PMNL → Polymorphonuclear leukocyte) Largest leukocyte → monocyte.

Tg:- @chanisle_neet

Circulatory pathways

Open circulatory system

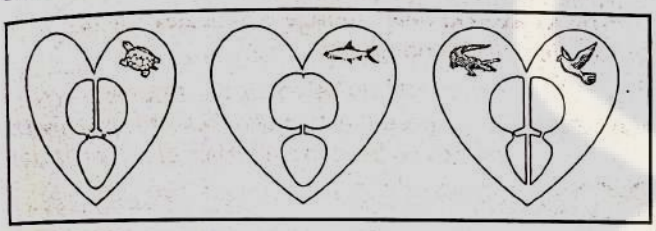
- Blood pumped by heart passes through large vessels into open spaces (cavities) k sinuses.
- Present in arthropods and molluscs

Closed circulatory system

- Blood pumped by the heart is circulated through a closed network of blood vessels.
- Present in Annelids and chordates

Structural differences in heart

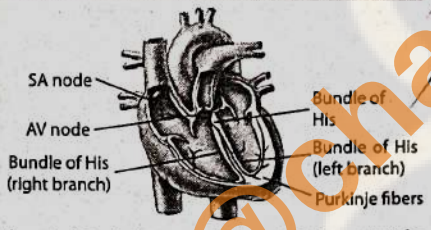
Fish	2 chambered heart (One atria and one ventricle)	Single circulation
Amphibian, reptiles (except crocodile)	3 chambered heart (Two atria and one ventricle)	Incomplete double circulation
Birds and mammals	4 chambered heart (Two atria and two ventricle)	double circulation



Human circulatory System

Heart

- Mesodermally derived organ
- Covered by double walled membranous bag, pericardium
- Pericardium encloses pericardial fluid



- The opening between the right atrium and the right ventricle is guarded by tricuspid valve
- The opening between the left atrium and the left ventricle is guarded by bicuspid / mitral valve
- The openings of the right and the left ventricles into the pulmonary artery and the aorta respectively are provided with the semilunar valves
- The walls of ventricles are much thicker than that of the atria

Cardiac conduction system

- Sino-atrial node (SA Node) : present in the right upper corner of the right atrium
- Atrio-ventricular node (AVN) : seen in the lower left corner of the right atrium
- Bundle of His
- Purkinje fibres

Heart nodes

- Made up of specialized cardiac **muscle** cell
- Auto excitable
- SAN generate action potentials, i.e., 70-75 per min, is called the pacemaker, responsible for initiating and maintaining the rhythmic contractile activity of the heart

Cardiac Cycle

- To begin with, all the four chambers of heart are in a relaxed state, i.e., they are in joint diastole
- As the tricuspid and bicuspid valves are open, blood from the pulmonary veins and vena cava flows into the left and the right ventricle respectively through the left and right atria
- SAN now generates an action potential ⟶ atrial systole ⟶ this increases the flow of blood into the ventricles by about 30 %
- Now ventricular contraction causes closure of tricuspid and bicuspid valve ⟶ followed by opening of semilunar valve ⟶ blood flows into pulmonary artery and aorta
- Ventricles relaxes

Blood volume

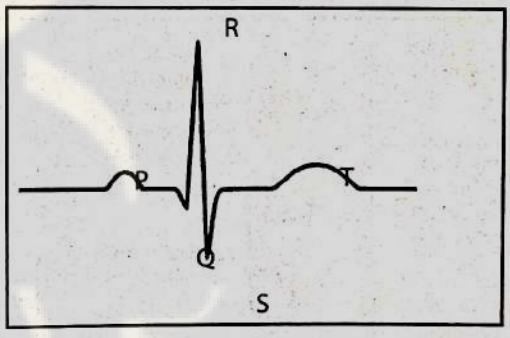
- Heart beats 72 times per minute
- Duration of a cardiac cycle is : 0.8 seconds
- **Stroke volume:** Blood pumped by ventricle one beat ⟶ 70 ml
- **Cardiac output:** Volume of blood pumped out by each ventricle per minute = 5000 mL or 5 litres

Heart sound

- Closure of the tricuspid and bicuspid valves ⟶ Lubb sound
- Closure of semilunar valve ⟶ Dubb sound

Electrocardiograph (ECG)

- P wave: Contraction / excitation / depolarization of the atria,
- QRS complex: Contraction / excitat^n / depolarization of ventricle
- By counting the number of QRS complexes that occur in a given time period, one can determine the heart beat rate of an individual
- T wave: repolarization / relaxation of ventricle
- The end of the T-wave marks the end of systole

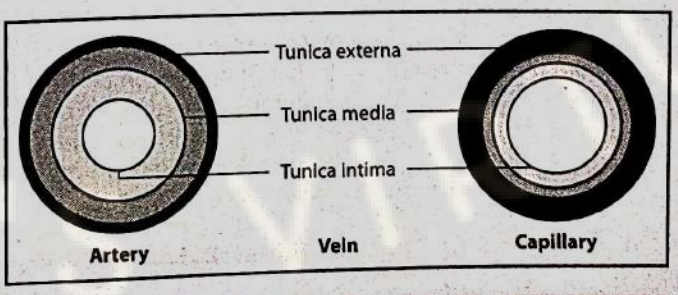


Double circulation

Blood Vessel, 3 layers

- Tunica intima: inner lining of squamous endothelium
- Tunica media: middle layer of smooth muscle (thin in the veins)
- Tunica externa: external layer of fibrous connective tissue

Note : Artery has narrow lumen as compared to vain



Tg:- @chanpsjee_neet

Hepatic portal system

- A unique vascular connection that exists between the digestive tract and liver is called Hepatic portal system
- The hepatic portal vein carries blood from intestine to the liver before it is delivered to the systemic circulation

Coronary system: supplies blood to heart

Regulation of cardiac activity

Intrinsic regulation

Normal activities of the heart are regulated intrinsically, i.e., **auto regulated** by specialised muscles (nodal tissue), hence the heart is called **myogenic**

Neural regulation

- **Medulla oblongata** can moderate the cardiac function through autonomic nervous system (ANS)
- **Sympathetic nerves** can *increase* the rate of heart beat, the strength of ventricular contraction and thereby cardiac output.
- **Parasympathetic nerves** can *decrease* the rate of heart beat, speed of conduction of action potential and thereby the cardiac output

Hormonal regulation

- Adrenal medullary hormones: increases cardiac output
- Atrial natriuretic factor (ANF): secreted by atria, decreases blood pressure

Disorders of circulatory system

High blood pressure

- If **repeated** checks of blood pressure of an individual is **140/90** or higher, then it shows hypertension
- High blood pressure affects vital organs like brain and kidney.

Coronary Artery Disease (atherosclerosis)

- It is the deposition of calcium, fat, **cholesterol** and fibrous tissues in the coronary arteries, this causes narrowing of vessels

Angina (Angina pectoris)

- Angina means **chest pain**
- More common among the middle-aged and elderly, appears when no enough oxygen is reaching the heart muscle

Heart Failure:

- Ineffective / decreased pumping of heart
- Also called as ***Congestive heart failure*** bcoz decrease pumping leads to congestion in lungs
- Heart failure is not the same as cardiac arrest
  - **Cardiac arrest:** heart stops beating
  - **Heart attack:** heart muscle is suddenly damaged by an inadequate blood supply

Tg:- @chanpsjee_neet

19. Excretory Products And Their Elimination

- Major forms of nitrogenous wastes ⟶ Ammonia, urea, uric acid
- Most toxic form ⟶ Ammonia, requires large amount of water for its elimination,
- Least toxic form ⟶ uric acid, can be removed with a minimum loss of water.

Ammonotelic animals

- The process of excreting ammonia is Ammonotelism.
- Many bony fishes, aquatic amphibians and aquatic insects are ammoniotelic in nature.
- Ammonia, as it is readily soluble, is generally excreted by diffusion across body surfaces or through gill surfaces (in fish) as ammonium ions
- Kidneys do not play any significant role in its removal

Ureotelic animals

- Ammonia produced by metabolism is converted into urea in the liver of these animals and released into the blood which is filtered and excreted out by the kidney
- Mammals, many terrestrial amphibians and marine fishes mainly excrete urea and are called ureotelic animals
- Some amount of urea is retained in the kidney matrix of some of these animals to maintain a desired osmolarity

Uricotelic animals

- Reptiles, birds, land snails and insects
- They excrete nitrogenous wastes as uric acid in the form of pellet or paste with a minimum loss of water and are called uricotelic animals.

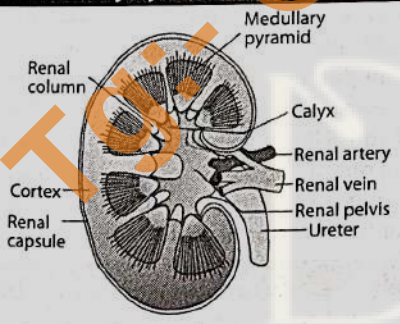
Excretory organs

- Platyhelminthes (Flatworms), Rotifers, annelids, cephalochordate – **Protonephridia (Flame cells)**
- Earthworm, other annelids – **Nephridia**
- Cockroach – **Malpighian tubule**
- Crustaceans like prawns – **Antennal glands or green glands**

Human Excretory System

Ureter, blood vessels and nerves enters kidney through hilum

Inner to the hilum is a broad funnel shaped space called the renal pelvis with projections called calyces.



The outer layer of kidney is a tough capsule

Inner region called medulla is divided into a few conical masses (medullary pyramids) projecting into the calyces

Outer region called cortex extends in between the medullary pyramids as renal columns called Columns of Bertin

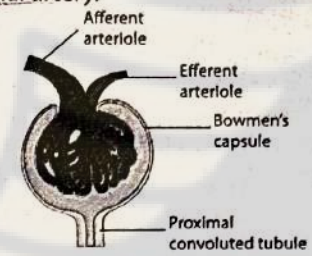
Location of kidney : last thoracic and third lumbar

Nephron

Each kidney has nearly one million nephrons

Each nephron has two parts – glomerulus and renal tubule

- Glomerulus is a tuft of capillaries formed by the afferent arteriole – a fine branch of renal artery.
- The renal tubule begins with a double walled cup-like structure called Bowman's capsule, which encloses the glomerulus
- Glomerulus + Bowman's = **Malpighian body or renal corpuscle**



Flow of urine

Glomerulus – PCT – Loop of Henle—DCT --- Collecting duct—Calyx—renal pelvis—ureter--- urinary bladder

Locations

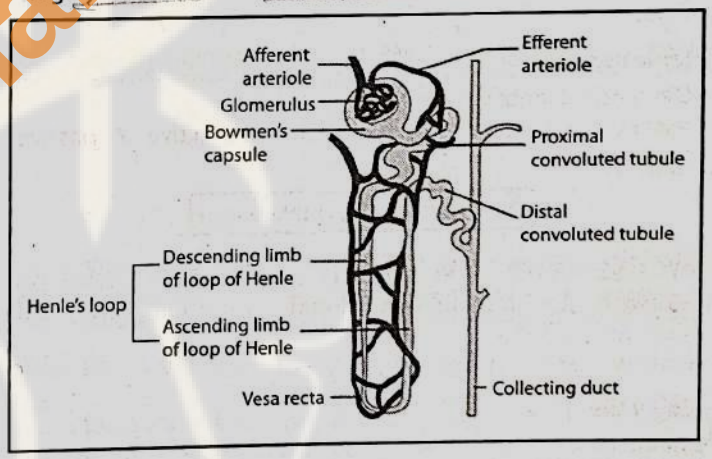
- Malphigian corpuscle, PCT and DCT ⟶ located in cortex
- Loop of Henle ⟶ extends to medulla

Types of Nephrons

- **Cortical nephrons :** Nephron with short loop of Henle located in cortex
- **Juxta medullary nephrons:** Nephron with long loop of Henle that runs deep into the medulla
- Majority of nephrons in kidney are Cortical nephrons

Capillaries around tubule

- The efferent arteriole emerging from the glomerulus forms a fine capillary network around the renal tubule called the peritubular capillaries
- A minute vessel of capillary network runs parallel to the Henle's loop forming a 'U' shaped vasa recta. Vasa recta is absent or highly reduced in cortical nephrons.



Urine formation

Glomerular filtration

- **Value**
  - First step in urine formation carried out by the glomerulus
  - 1100-1200 ml of blood is filtered per minute
  - The amount of the filtrate formed by the kidneys per minute is called glomerular filtration rate (GFR). GFR in a healthy individual is approx 125 ml/minute, i.e., 180 lit per day
- **Glomerular filtration barrier**
  - Endothelium of glomerular blood vessels,
  - Basement membrane
  - Epithelium of Bowman's capsule

Tg: @champsie_neet

- **Podocytes**
  - The **inner** visceral epithelial cells of Bowman's capsule called Podocytes are arranged in an intricate manner so as to leave some minute spaces called filtration slits or slit pores.
- **Ultrafiltration**
  - Blood is filtered so finely through these membranes, that almost all the constituents of the plasma except the proteins pass onto the lumen of the Bowman's capsule. Therefore, it is considered as a process of ultra-filtration
- **Juxta glomerular apparatus (JGA)**
  - formed by cellular modifications in the distal convoluted tubule and the afferent arteriole at the location of their contact
  - When GFR falls ⟶ JG cells get activated ⟶ renin is released ⟶ Systemic vasoconstriction ⟶ Glomerular blood flow increases ⟶ GFR backs to normal

Tubular Reabsorption

- Filtrate formed per day (180 litres per day) - urine released (1.5 liters): 99 % of the filtrate is reabsorbed by the renal tubules
- Active absorption: Glucose, amino acids, Na+
- Passive absorption: Water, Urea

Tubular secretion

- Tubular cells secrete substances like H+, K+ and ammonia into the filtrate

Function of the tubules

Proximal Convoluted Tubule (PCT)

- Lined by simple cuboidal brush border epithelium
- **Reabsorb :** all of the essential nutrients, and 70-80 per cent of electrolytes, water, Bicarbonates, Na+, $C_6H_{12}O_6$, Carbo
- **Secretes :** hydrogen ions, ammonia and potassium ions into the filtrate ⟶ maintain pH and ionic balance of the body fluids

Henle's Loop

- Descending limb (permeable to water)
- Ascending limb: reabsorb electrolytes active / passive transport

Descending limb drinks water

Distal Convoluted Tubule (DCT)

Reabsorb: Bicarbonate, conditional reabsorption of Na and water reabsorption ⊙ Bicarbonate

Secretes: hydrogen ions, ammonia and potassium

Collecting Duct

- **Reabsorb:** water, urea (pass it to interstitium to keep osmolality)
- **Secretes:** hydrogen ions and potassium, ammonium ions

Mechanism of concentration of the filtrate

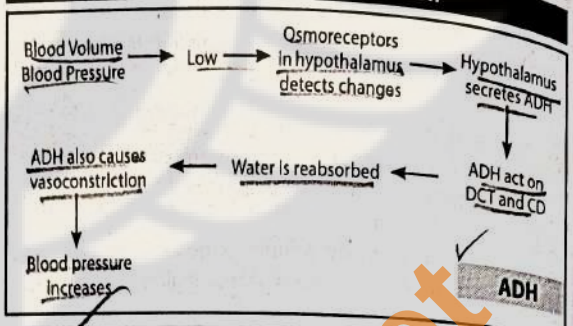
- The flow of blood through the two limbs of vasa recta and Henle's loop is in opposite directions and thus forms a counter current
- Counter current creates and maintains medullary osmotic gradient 300 mOsmolL−1 in the cortex to about 1200 mOsmolL−1 in the inner medulla
- This gradient is mainly caused by **NaCl and urea**
- Presence of counter current mechanism produce urine nearly four times concentrated than the initial filtrate formed

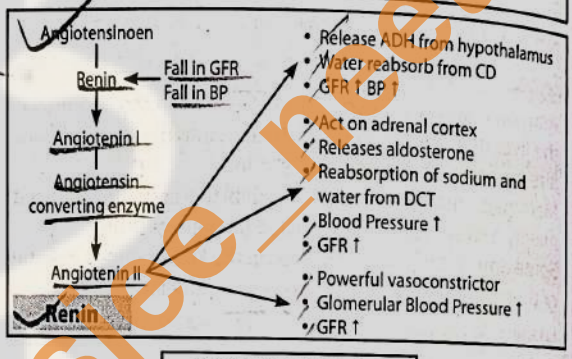
* Mammals have the ability to produce a Conc urine

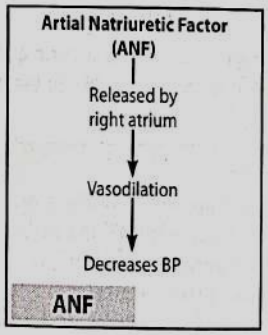
Role of other organs in excretion

- **Lungs** remove CO_2
- **Liver** secretes bilirubin, biliverdin, cholesterol, drugs etc
- **Sweat glands** secretes NaCl, urea, lactic acid, etc
- **Sebaceous gland** secretes sterols, hydrocarbons and waxes

Regulation of kidney function







Micturition

Urine fills in urinary bladder ⟶ Stretch receptors gets stimulated ⟶ sends impulses to CNS (**Pons**) ⟶ CNS sends impulse through motor nerve ⟶ causes Contraction of bladder & relaxation of urethral sphincter ⟶ Urine is released

- The process of release of urine is called micturition and the neural mechanisms causing it is called the micturition reflex
- 1 to 1.5 litres of urine is passed per day
- 30 gm of urea is excreted out per day

Diabetes Mellitus may show presence of glucose (Glycosuria) and ketone bodies (Ketonuria) in urine

Disorders of the excretory system

- Renal calculi: Stone or insoluble mass of crystallised salts (oxalates, etc.) formed within the kidney.
- Glomerulonephritis: Inflammation of glomeruli of kidney.
- Uraemia:
  - Accumulation of urea in blood
  - Urea can be removed by a process called hemodialysis.
- Drain blood from artery, add **heparin**, dialysing fluid having same constituent as plasma except nitrogenous waste, return blood through vein
- Renal failures (kidney failure)
- Kidney transplantation is the ultimate method in the correction of acute renal failures (kidney failure)

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20. Locomotion and Movement

Types of movement

Amoeboid movement

Some cells like macrophages and leucocytes in blood exhibit amoeboid movement.
It is effected by formation of pseudopodia (as in Amoeba).
Cytoskeleton involved: **Microfilament**

Ciliary movement

- Cilia in trachea help in removing dust particles
- Cilia also help passage of ova through fallopian tube
- Cytoskeleton involved: **Microtubules**

Flagellar movement

Flagellar movement helps in:
- the swimming of spermatozoa
- maintenance of water current in the canal system of sponges
- locomotion of Protozoans like Euglena
- Cytoskeleton involved: **Microtubules**

Muscular movement

Movement of our limbs, jaws, tongue, etc, require muscular movement.

Muscle

- Muscle is a specialized tissue of mesodermal origin
- Properties of muscle: excitability, contractility, extensibility and Elasticity etc
- Based on location, there are three types of muscles

Skeletal muscles	Visceral muscles	Cardiac muscles
Associated with the skeletal components of the body	Located in the inner walls of hollow visceral organs of the body like the alimentary canal, reproductive tract etc.	Muscles of heart
They have striped apperance under the microscope and hence are called **striated** muscles	They do not exhibit any striation and are smooth in appearance, hence called **smooth** muscles (nonstriated muscle)	Based on apperance, cardiac muscle are **striated**. They also show **branching**
Their activities are under voluntary control (**voluntary muscles**)	Their activities are not under the voluntary control (**involuntary muscles**)	They are **involuntary** in nature

Note : Cardiac muscle consists of individual heart muscle cells connected by **intercalated discs** to work as a single functional organ

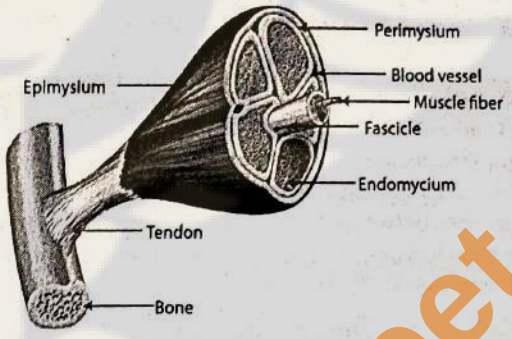
Skeletal muscle

- Skeletal muscle is made of a number of **muscle bundles** or fascicles held together by a common collagenous connective tissue layer called **fascia**
- Each muscle bundle contains a number of muscle fibres (muscle cell), which is structural unit of muscle

Structure of muscle fibre (muscle cell)
- Plasma membrane of muscle fiber ⟶ sarcolemma
- Protoplasm of muscle fiber ⟶ Sarcoplasm
- Sarcoplasm contains many nuclei ⟶ syncytium
- Endoplasmic reticulum of the muscle fibers ⟶ sarcoplasmic reticulum. It is the **store house of calcium ions**

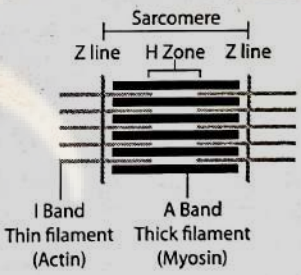
Characteristic feature of the muscle fibre

Presence of a large number of parallelly arranged filaments in the sarcoplasm called myofilaments or myofibrils.
Muscle fire is the anatomical unit of muscle.



Myofibril:

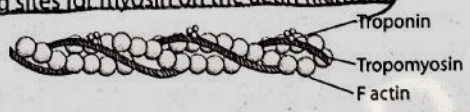
- Each myofibril has alternate thin and thick filament
- Thin filament = actin filament = I band = Isotropic band = light band.
- Thick filament = myosin filament = A band = anisotropic band = Dark band
- Distribution pattern of Actin and Myosin gives striated appearance to skeletal muscle.
- Elastic fibre called 'Z' line bisects thin filament
- Elastic fibre called M line bisect thick filament
- The portion of the myofibril between two successive 'Z' lines is considered as the functional unit of contraction and is called a sarcomere (Functional unit of muscle contraction)
- In a resting state, the central part of thick filament, not overlapped by thin filaments is called the 'H' zone



Structure of Contractile Proteins

Actin (thin) filament

- Each actin filament is made of two 'F' (filamentous) actins
- Each 'F' actin is a polymer of monomeric 'G' (Globular) actins.
- Two filaments of another protein, tropomyosin also run close to the 'F' actins throughout its length.
- A complex protein (troponin) is distributed at regular intervals on the tropomyosin
- In the resting state, a subunit of troponin masks the active binding sites for myosin on the actin filaments

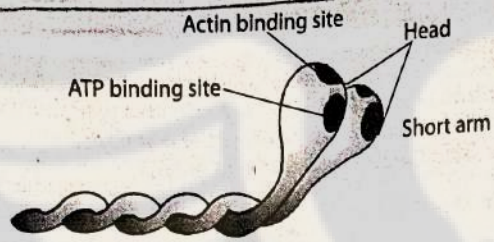


Myosin (thick) filament

- Myosin filament is made of monomeric proteins- Meromyosins
- Each meromyosin has short arm (heavy meromyosin) and a tail (light meromyosin).

Tg: @champion_neet

- The globular head is an active ATPase enzyme and has binding sites for ATP and active sites for actin



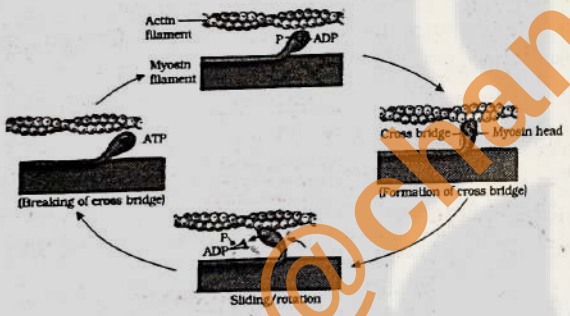
Mechanism of Muscle Contraction

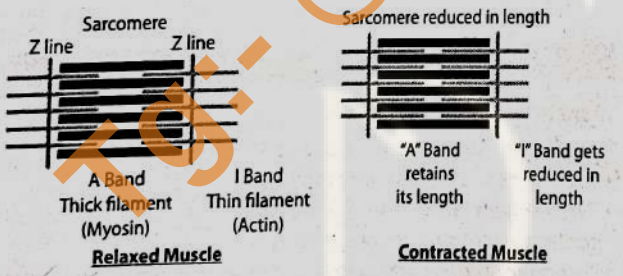
Sliding filament theory

- A motor neuron along with the muscle fibers connected to it constitute a **motor unit**
- The junction between a motor neuron and the sarcolemma of the muscle fiber is called the neuromuscular junction or **motor-end plate**. M-N Jun

For muscle contraction

1. Neural signal reach neuro muscular junction
2. N-M junction releases **acetyl choline** IMP
3. action potential is generated in the sarcolemma
4. action potential release calcium ions into the sarcoplasm
5. **Calcium binds to troponin** and remove the masking of active sites for myosin
6. Myosin binds to actin utilizing **ATP**
7. Actin myosin **cross bridge** is formed
8. Myosin pulls actin filament towards the centre of actin filament
9. **Actin slides over myosin**
10. This causes shortening of the sarcomere, i.e., contraction





On muscle contraction

- Sarcomere shortens
- H zone Hides (disappear)
- A band remains same (Avenger remains unchanged)
- I band decreases

For muscle relaxation (ATP hydrolyed by myosin)

1. ATP binds and the cross-bridge is broken
2. Ca^{++} ions are pumped back to the sarcoplasmic reticulum
3. Masking of actin filament takes place

Muscle fatigue

Repeated activation of the muscles can lead to the accumulation of lactic acid due to anaerobic breakdown of glycogen in them, causing fatigue.

Types of muscle fibres

- Red muscle fibres
- White muscle fibres

Red muscle Fibres	White muscle fibres
Myoglobin, an oxygen storing red pigment content is high	Less quantity of myoglobin hence appears white
Less amount of sarcoplasmic reticulum	More amount of sarcoplasmic reticulum
Plenty of mitochondria	Few mitochondria
Use oxygen - aerobic muscle	Anaerobic muscle

SKELETAL SYSTEM

- Bone and cartilage are specialized connective tissues.
- Bone has a very hard matrix due to calcium salts in it and the cartilage has slightly pliable matrix due to chondroitin salts.
- Human beings have 206 bones
- Two principal divisions of skeletal system
  - the axial and the appendicular skeleton

Axial skeleton

- Axial skeleton comprises 80 bones
- Axial skeleton has skull, vertebral column, sternum and ribs

Skull (22 bones)

The skull is composed of two sets of bones cranial (8) and facial (14), that totals to 22 bones

Cranial bones (8 Bones) Paired

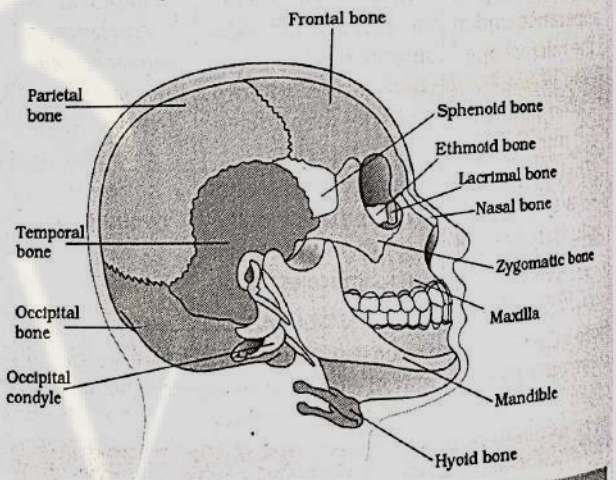
Frontal, Parietal (2), Temporal (2), Occipital, Ethmoid, Sphenoid

Facial Bones (14 bones) Unpaired

Maxilla (2), Zygomatic (2), **Mandible** (1), Nasal (2), Platine (2) Lacrimal (2), Inferior nasal concha (2), **Vomer** (1)

Note : Mandible and Vomer are the only unpaired facial bones

A single U-shaped bone called hyoid is present at the base of the buccal cavity and it is also included in the skull



Ear ossicles

Malleus, Incus, Stapes

Vertebral column

- Formed by 26 vertebrae 7 12 5 1 1
- The vertebral column is differentiated into cervical (7), thoracic (12), lumbar (5), sacral (1-fused) and coccygeal (1-fused)
- Each vertebra has a central hollow portion (neural canal) through which the spinal cord passes
- ***Presence of 7 cervical vertebrae is characteristic of all mammals***

Tg:- @channelee_neet

- First vertebra is the atlas and it articulates with the occipital condyles.
- The vertebral column protects the spinal cord, supports the head and serves as the point of attachment for the ribs and musculature of the back

Sternum

- Sternum is a flat bone on the ventral midline of thorax

Ribs

- There are 12 pairs of ribs.
- Each rib connected dorsally to the vertebral column and ventrally to the sternum.
- It has two articulation surfaces on its dorsal end and is hence called **bicephalic**.

True ribs

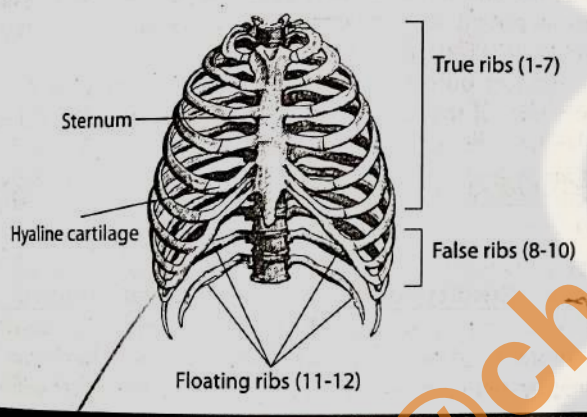
- First seven pairs of ribs are called true ribs.
- Dorsally, they are attached to the thoracic vertebrae and ventrally connected to the sternum with the help of **hyaline cartilage**

False ribs

- The 8th, 9th and 10th pairs of ribs do not articulate directly with the sternum but join the seventh rib with the help of hyaline cartilage

Floating ribs

- Last 2 pairs (11th and 12th) of ribs are not connected ventrally and are therefore, called floating ribs.



Appendicular skeleton

The bones of the limbs along with their girdles constitute the appendicular skeleton.

Forelimb

The bones of the hand (fore limb) are humerus, radius and ulna, carpals (wrist bones – 8 in number), metacarpals (palm bones – 5 in number) and phalanges (digits – 14 in number)

Hindlimb

The bones of the leg (Hind limb) Femur (thigh bone – the longest bone), tibia and fibula, tarsals (ankle bones – 7 in number), metatarsals (5 in number) and phalanges (digits – 14 in number)

Pectoral Girdle

Each pectoral girdle consists of a clavicle and a scapula

Scapula

- Triangular flat bone
- Located between the second and the seventh ribs.
- Elevated ridge called acromion.
- Acromion process of scapula articulates with clavicle
- **Glenoid cavity** of scapula articulates with the head of humerus

Clavicle

- Clavicle is called the collar bone
- Clavicle connects axial skeleton with appendicular skeleton

Pelvic Girdle

- Pelvic girdle consists of two coxal bones
- Each coxal bone is formed by the fusion of three bones – ilium, Ischium and pubis.
- **Acetabulum** cavity of coxal bone articulates with femur bone
- The two halves of the pelvic girdle meet ventrally to form the pubic symphysis containing **fibrous cartilage**.

Joints

Fibrous joints

- Fibrous joints do not allow any movement
- E.g., Joints between skull bone.

Cartilaginous joints

- Permits limited movements.
  - Joint between the adjacent vertebrae
  - Joints between rib and sternum (Hyaline cartilage)
  - Pubic symphysis (Fibrous cartilage)

Synovial joints

- Characterized by the presence of a fluid filled synovial cavity between the articulating surfaces of the two bones allows considerable movement.
- **Types**
  1. Ball and socket joint (betn humerus and pectoral girdle),
  2. Hinge joint (knee joint),
  3. Pivot joint (between atlas and axis),
  4. Gliding joint (between the carpals, tarsal)
  5. Saddle joint (between carpal and metacarpal of thumb)

Disorders of muscular and skeletal system

Myasthenia gravis

Auto immune disorder affecting neuromuscular junction leading to fatigue, weakening and paralysis of skeletal muscle.

Muscular dystrophy

Progressive degeneration of skeletal muscle mostly due to genetic disorder. It is an autosomal dominant diseases.

Tetany

Rapid spasms (wild contractions) in muscle due to low Ca^{++} in body fluid.

Arthritis

Inflammation of joints.

Osteoporosis

Age-related disorder characterised by decreased bone mass and increased chances of fractures. Decreased levels of **Estrogen** (post-menopausal women) is a common cause.

Gout

Inflammation of joints due to accumulation of uric acid crystals

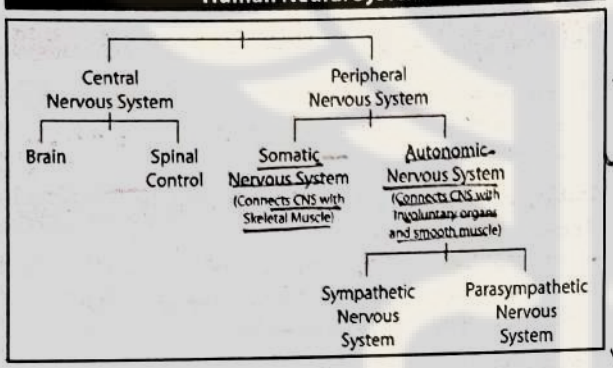
Tg:- @chanpjee_reet

21. Neural Control And Coordination

Neural System

- Lower vertebrate e.g. Hydra: simple neurons.
- Insect (e.g. cockroach): Nervous system in the form of ventral ganglia (Dorsally located)
- Vertebrates have more developed neural system

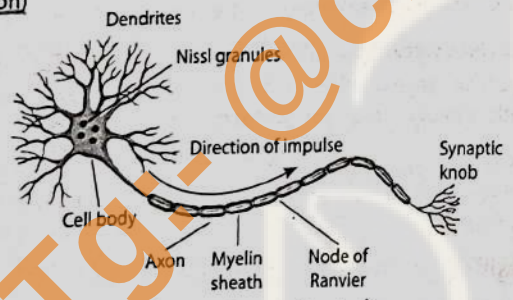
Human Neural System



The nerve fibres of the PNS are of two types :
afferent fibres and efferent fibres
The afferent nerve fibres transmit impulses from tissues/organs to the CNS and the efferent fibres transmit regulatory impulses from the CNS to the concerned peripheral tissues/organs.

Neuron

- Neuron is a structural and functional unit of neural system
- **Dendrite** : Short fibres which branch repeatedly and project out of the cell body
- **Axon** : long fibre, the distal end of which is branched. Each branch terminates as a bulb-like structure called synaptic knob which possess synaptic vesicles containing chemicals called neurotransmitters → Dendrite & Cell Body
- **Nissles granules** : grey colored bodies, these are rough endoplasmic reticulum found in cyton and dendrites (not in axon)



- **Transmission of impulse** D → C → A
  - Dendrites transmits impulse towards cell body
  - Axon carry impulse away from cell body or to synapse
- Types of neurons

Type	Axon / dendrite	Location
Unipolar	Cell body with one axon	Embryonic stage
Bipolar	Cell body with one axon and one dendrite	Retina of eye
Multipolar	Cell body with one axon and two or more dendrite	Cerebral cortex

- Myelin sheath
  - Made up of sphingolipid and protein
  - In CNS Myelin sheath is formed by Oligodendrocyte cell
  - In PNS Myelin sheath is formed by Schwann cell
  - Two types of Schwan cells
    - Schwan cells that form myelin sheath : found in somatic system
    - Schwan cell that do not form myelin sheath : found in autonomic and somatic system

Generation and Conduction of Nerve Impulse

At rest

- More Potassium ion in axoplasm and More sodium ions in fluid outside axon
- Inner side of axon is negatively charged bcoz of Potassium ions leaking to outside and presence of negatively charged protein
- The outer surface of the axonal membrane possesses a positive charge while its inner surface possesses negatively charged
- At rest neuron is in polarized state

When a stimulus is applied

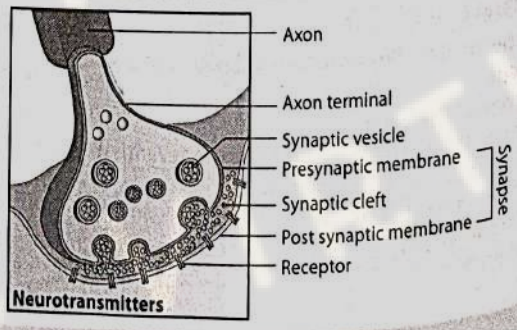
- Neuron becomes freely permeable to Na^+. This leads to a rapid influx of Na^+ followed by the reversal of the polarity at that site, i.e., the outer surface of the membrane becomes negatively charged and the inner side becomes positively charged ⟶ action potential or nerve impulse generates
- Influx if Na is short lived
- K^+ diffuses outside the membrane and restores the resting potential of the membrane at the site of excitation and the fibre becomes once more responsive to further stimulation

Transmission of Impulses

A synapse is formed by the membranes of a pre-synaptic neuron and a post-synaptic neuron

Electrical synapses	Chemical synapses
At electrical synapses, the membranes of pre- and post-synaptic neurons are in very close proximity, rare in body	**Synaptic cleft** is present between pre- and post-synaptic neurons, commonly found in body
Electrical current can flow directly from one neuron into the other	**Neurotransmitter** is required
Impulse transmission is fast	Impulse transmission is slower

Impulse (action potential) arrives at the axon terminal, it stimulates the movement of the synaptic vesicles towards the membrane where they fuse with the plasma membrane and release their neurotransmitters in the synaptic cleft. The released neurotransmitters bind to their specific receptors, present on the post-synaptic membrane. This binding opens ion channels allowing the entry of ions which can generate a new potential in the post-synaptic neuron.



Tg- @champion_neet

Central Neural System

The brain is covered by 3 layered structure: cranial meninges
1) outer layer called dura mater
2) middle layer called arachnoid
3) inner layer (in contact with the brain tissue) called pia mater

Fore brain

The forebrain consists of cerebrum, thalamus and hypothalamus

Cerebrum

- Cerebrum forms the major part of the human brain
- Corpus callosum connects right and left cerebral hemisphere
- Cerebrum consist of outer Cerebral cortex (grey matter) and inner cerebral medulla
- Cerebral cortex contains motor areas, sensory areas and large association area

Thalamus

- Coordinating centre for sensory & motor signalling (relay centre).

Hypothalamus

- Neural role: Control body temperature, urge for eating , drinking.
- Hormonal role : It contains several groups of neurosecretory cells, which secrete hormones called hypothalamic hormones.

Limbic system

- It is a structure formed by neurons from Hippocampus, Hypothalamus, Amygdala and Thalamus
- It is involved in regulation of sexual behavior, expression of emotional reactions (e.g., excitement, pleasure and fear), and motivation.

Hippo HAT

Midbrain

- Located between the thalamus/hypothalamus of the forebrain and pons of the hindbrain
- A canal called the **cerebral aqueduct** passes through the midbrain. The dorsal portion of the midbrain consists mainly of four round swellings (lobes) called **corpora quadrigemina**

Hindbrain

The hindbrain comprises pons, cerebellum and medulla

Pons	Pneumotaxic, micturition centre
Medulla	Controls involuntary movements, respiration, cardiovascular reflexes and gastric secretions → Vomiting centre
Cerebellum	has convoluted surface, Helps in coordination of Movement

Brain stem = Midbrain + Pons + Medulla

Reflex Action and Reflex Arc

The entire process of response to a peripheral nervous stimulation, that occurs involuntarily, i.e., without conscious effort or thought and requires the involvement of a part of the central nervous system is called a reflex action

Reflex arc

Afferent neuron → a dorsal nerve root → spinal cord → efferent neuron → effector

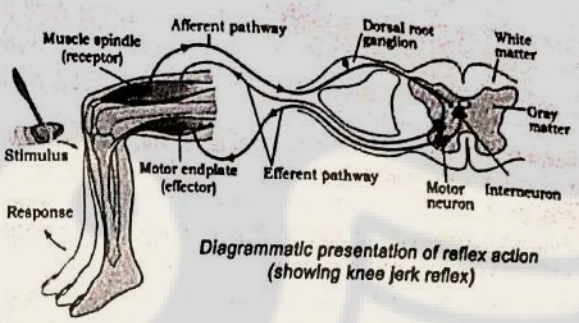
Dorsal root : sensory neuron

Ventral root : motor neuron

Savesh Dixit

Motor Jam

Outer → White matter Spinal cord Inner → Grey matter



Diagrammatic presentation of reflex action (showing knee jerk reflex)

Sense Organs

Nose

Mucus coated olfactory receptors are made up of Supporting epithelial cells, Basal cell and olfactory receptors → Smell
The neurons of the olfactory epithelium forms olfactory bulb

Tongue

The tongue detects tastes through taste buds, containing gustatory receptors → Taste.

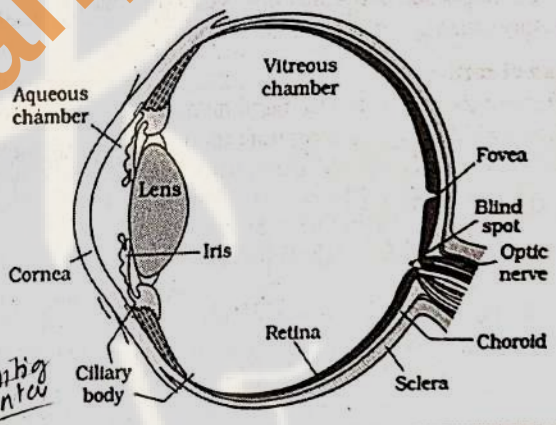
Eye

External layer

- Composed of a dense connective tissue and is called the sclera
- The anterior portion of this layer is called the cornea.

Middle layer

- Vascular layer called as choroid
- Choroid becomes thick in the anterior part to form the ciliary body
- Pigmented structure - Iris
- Transparent crystalline lens which is held in place by ligaments attached to the ciliary body



Inner layer

- Retina contains three layers of neural cells –from inside to outside – ganglion cells, bipolar cells and photoreceptor cells.
- Two types of photoreceptor cells, namely, **rods** and **cone**

Rods	Cones
Twilight (scotopic) vision, night vision	Daylight (photopic) vision and colour vision
The rods contain a purplish-red protein called the rhodopsin or visual purple	Cones contain three types of iodopsin, responds to red, green, blue color
Rhodopsin is composed of opsin (a protein) and retinal (an aldehyde of vitamin A) ***Rods Raat ko dekhne me help karenge***	---------- ***Cones for color***

TG:- @chandsjee_neet

- Optic nerves leave eye at blind spot, Photoreceptor cells are not present in this region and hence it is called the blind spot.
- Yellow color spot on retina is called macula, centre of macula is called **fovea centralis**.
- Fovea centralis have densely packed cones (no rods)
- It is the point where the visual acuity (resolution) is the greatest
  - Space between the cornea and the lens : aqueous chamber : filled with aqueous humor.
  - Space between lens and retina : vitreous chamber : filled with gel like vitreous humor

Mechanism of Vision

Light induces ***dissociation*** of the retinal from opsin ⟶ membrane permeability of photoreceptor changes ⟶ potential differences are generated in the photoreceptor cells ⟶ this generates action potentials in the ganglion cells through the bipolar cells ⟶ (impulses) are transmitted by the optic nerves to the visual cortex area of the brain ⟶ image is formed

Glandular Epithe

Ear

Outer ear : Pinna and external auditory meatus (have wax), tympanic membrane (the ear drum) composed of connective tissues covered with skin outside and with mucus membrane inside

Middle ear : malleus, incus and stapes, The malleus is attached to the tympanic membrane and the stapes is attached to the oval window of the cochlea. Eustachian tube connects the middle ear cavity with the pharynx

Inner ear : fluid-filled inner ear called labyrinth consists of two parts, the bony and the membranous labyrinths.

Bony labyrinth ⟶ Perilymph (Blood Plasma)

Membranous labyrinth ⟶ Endolymph (EM)

Cochlea

- The coiled portion of the labyrinth is called cochlea
- Sensory organ of cochlea : Organ of corti

Organ of corti

- Location: Located on basilar membrane
- Consist of Auditory receptors (Hair cells)

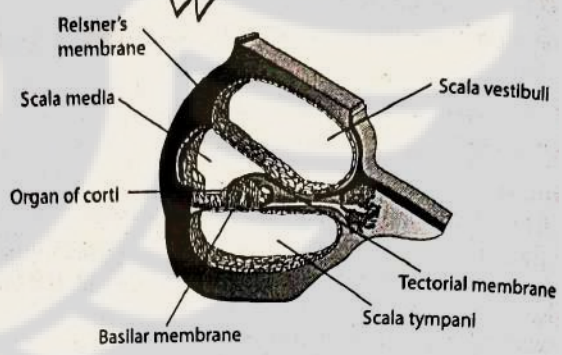
Scala vestibuli : filled with perilymph
Reissner's membrane

Scala media : filled with endolymph
Basilar membrane.

Scala tympani : filled with perilymph.

- Thin elastic membrane called tectorial membrane
- Function : responsible for hearing

Sectional View of Cochlea



Vestibular apparatus

Composed of three semi-circular canals and the otolith (mac is the sensory part of Saccule and utricle)

- Semi-circular canal
  - Each semi-circular canal lies in a different plane at ri angles to each other
  - Sensory part: crista ampularis
  - Function: balancing in rotational movement
- Saccule and utricle (otolith organs)
  - Sensory part: Macula
  - Function: maintenance of balance of the body a posture

Mechanism of Hearing

Sound wave vibration ⟶ tympanic membrane ⟶ malle incus **stapes** ⟶ **Oval window** ⟶ vibrations in perilymph – ripple in basilar membrane ⟶ hair cells bend against tecto membrane ⟶ nerve impulse generates in afferent neuron – auditory nerve (cochlear nerve) ⟶ auditory cortex of bra ⟶ sound is recognised

Tg:- @chanpsc_neet

22. Chemical Coordination and Integration

Endocrine Gland	Exocrine gland
Endocrine glands lack ducts hence, called as ductless glands	Exocrine glands bear duct
Their secretions are called hormones	Their secretions are called enzymes
Hormones are released into the blood	Enzymes are released locally through duct
Transported to a distantly located target organ	Transported locally
E.g. Pituitary gland	E.g. Salivary gland

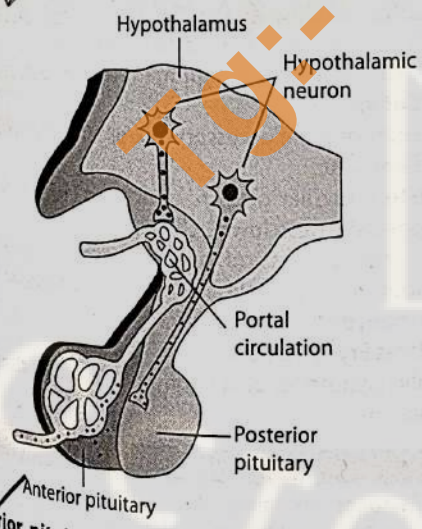
Hormones are :
- Non-nutrient chemicals
- Act as intercellular messengers
- Produced in trace amounts

Hypothalamus

- Hypothalamus is the basal part of diencephalon, forebrain
- It contains several groups of neurosecretory cells called nuclei which produce hormones.
- Hypothalamus controls functions of :
  - Anterior pituitary gland by secreting hormones.
  - Posterior pituitary gland by direct neuronal regulation
- Hypothalamic hormones reach anterior pituitary gland through a portal circulatory system
- Hormones produced by hypothalamus are of two types,
  - Releasing hormones (which stimulate secretion of pituitary hormones) E.g. Gonadotropin releasing hormone
  - Inhibiting hormones (which inhibit secretions of pituitary hormones) **somatostatin** inhibits the release of growth hormone from the pituitary

The Pituitary Gland

- Located in a bony cavity called **sella tursica**
- It is divided into two parts
  - Adenohypophysis
    - Pars distalis (anterior pituitary) and
    - Pars intermedia
  - Neurohypophysis
    - Also k/a Pars nervosa (Post Pituitary)



- **Anterior pituitary secretes**
  - Growth hormone (GH), prolactin (PRL), thyroid stimulating hormone (TSH), adrenocorticotrophic hormone (ACTH), luteinizing hormone (LH) , follicle stimulating hormone
- **Pars intermedia secretes**
  - Melanocyte stimulating hormone (MSH)
- **Posterior pituitary secretes**
  - Oxytocin and vasopressin actually synthesised by the hypothalamus and are transported to neurohypophysis.

Hormones of Pituitary Gland	
Growth hormone	Over secretion : Gigantism Under secretion : Dwarfism
TSH	Stimulates the synthesis and secretion of thyroid hormones from the thyroid gland
ACTH	Stimulates secretion of glucocorticoid from adrenal medulla
LH	Male : LH act on leydig cell ⟶ testosterone Female : LH induces ovulation, maintain corpus luteum
FSH	Male : FSH act on Sertoli cell – spermatogenesis Female : FSH is responsible for growth and development of the ovarian follicles
MSH	Acts on the melanocytes (melanin containing cells) and regulates pigmentation of the skin.
Oxytocin	Stimulates uterine contraction
Vasopressin (ADH)	Act on kidney : reabsorption of water and electrolytes by the distal tubules

Pineal Gland

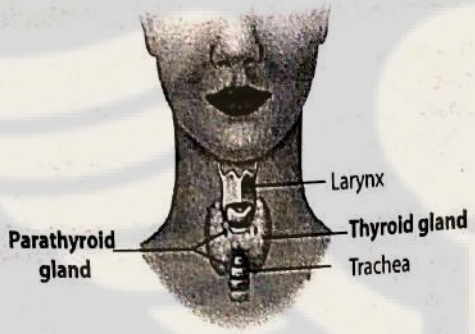
- Located on the dorsal side of forebrain
- Pineal gland secretes a hormone called melatonin.
- Maintains **24-hour (diurnal) rhythm**
- Maintains **sleep-wake cycle**, body temperature
- Influences pigmentation, the menstrual cycle & defence capability

Thyroid Gland

- Composed of two lobes joined by isthmus
- Composed of follicles and stromal tissues
- Each thyroid follicle is composed of follicular cells, enclosing a cavity
- These follicular cells synthesise two hormones, Tetraiodothyronine **or thyroxine (T4)** and triiodothyronine (T3)
- **Iodine** is essential for synthesis of thyroid hormone
- Deficiency of iodine in our diet results in hypothyroidism and enlargement of the thyroid gland, commonly called goitre
- Hypothyroidism during pregnancy : causes stunted growth (**cretinism**), mental retardation, low intelligence quotient, abnormal skin, deaf- mutism in baby
- **Hypothyroidism in women:** causes irregular menstrual cycle
- **Hyperthyroidism**; excessive secretion of thyroxine, can be due to cancerous thyroid nodule, affects body physiology
- **Exophthalmic goitre** is a form of hyperthyroidism, characterised by enlargement of the thyroid gland, protrusion of the eyeballs, increased basal metabolic rate, and weight loss, also called **Graves' disease**
- Functions of Thyroid hormone
  - Regulates Basal metabolic rate, red blood cell formation, metabolism of carbohydrates, proteins and fats, water and electrolyte balance

Tg:- @champsee_neet

Thyroid gland also secretes thyrocalcitonin (TCT) which regulates (decreases) blood calcium levels.



Parathyroid Gland

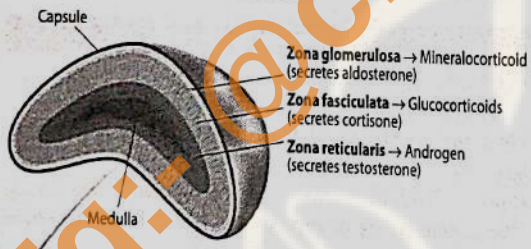
- 4 parathyroid glands are present on back side of thyroid gland
- Secrete parathyroid hormone (PTH)
- PTH is called as **hypercalcaemic** hormone
- PTH increases the Ca^{2+} levels in the blood by :
  - Bone resorption
  - Reabsorption of Ca^{2+} by the renal tubules,
  - Absorption of calcium from food

Thymus

- Located behind sternum, between lungs
- Secretes thymosins hormone
- Promotes production of T-lymphocytes (**cell-mediated immunity**)
- Promotes production of antibodies (**humoral immunity**)
- Thymus is degenerated in old individuals ⟶ immune responses of old persons become weak.

Adrenal Gland

- Our body has one pair of adrenal glands, one at the anterior part of each kidney.
- The gland is composed of two types of tissues : Central adrenal medulla, and outer adrenal cortex



Adrenal Medulla

- Adrenal medulla secretes adrenaline or epinephrine and **noradrenaline** or norepinephrine
- Adrenaline and noradrenaline are called emergency hormones or hormones of Fight or Flight
- Increase alertness, pupillary dilation, piloerection (raising of hairs), sweating etc., breakdown of lipids and proteins and glycogen (to increase Glucose level)

Adrenal cortex

Zones of adrenal cortex from outer to inner

Zone	Hormones
Zona glomerulosa	Mineralocorticoid (e.g. aldosterone)
Zona fasciculata	Glucocorticoid (e.g. cortisol)
Zona reticularis	Androgen (testosterone / oestrogen)

Hormones of adrenal cortex are collectively k/a corticoids

Glucocorticoid (e.g., Cortisol)

- Stimulate **gluconeogenesis** (process that transforms non-carbohydrate substrates) (e.g., amino acids, into glucose), lipolysis and proteolysis
- Inhibit cellular uptake and utilisation of amino acids
- Glucocorticoids, particularly **cortisol**, produces anti-inflammatory reactions and suppresses the immune response
- Stimulate RBC production

Mineralocorticoid (e.g. Aldosterone)

- Stimulates the reabsorption of Na^+ and water and excretion of K^+ and phosphate ions from distal tubule
- Maintains body fluid volume, osmotic pressure and blood pressure

Androgens

- Play a role in the growth of axial hair, pubic hair and facial hair during puberty

Note : Underproduction of hormones by the adrenal cortex alters carbohydrate metabolism causing acute weakness and fatigue leading to a disease called **Addison's disease**.

Pancreas

Pancreas is a composite gland which acts as both exocrine and endocrine gland. The endocrine pancreas consists of islets of **Langerhans'**.

Glucagon	Insulin
Secreted by alpha cells of islets of Langerhans	Secreted by beta cells of islets of Langerhans
Act mainly on hepatocytes	Act mainly on hepatocytes
Stimulates glycogenolysis and gluconeogenesis ⟶ blood glucose increases	Stimulate glycogenesis ⟶ Synthesis of glycogen from glucose ⟶ Blood glucose decreases
Reduces cellular uptake of glucose	Increases cellular uptake of glucose
Hyperglycaemic hormone	Hypoglycaemic hormone

Prolonged hyperglycaemia leads to a complex disorder called **diabetes mellitus**. Loss of glucose through urine and formation of harmful compounds known as ketone bodies.

Testis

- Leydig cells (interstitial cells) of testis in response to LH produce a group of hormones called androgens mainly testosterone
- **Functions of androgen**
  - Maturation of male accessory sex organs like epididymis, vas deferens etc.
  - Stimulate muscular growth, growth of facial and axillary hair, aggressiveness, low pitch of voice etc.
  - Role in the process of spermatogenesis, male sexual behaviour (libido), anabolic (synthetic) effects on protein and carbohydrate metabolism.
  - Stimulates Erythropoiesis
  - Anabolic (synthetic) effects on protein and carbohydrate metabolism.

Ovary

- Produces Estrogen and progesterone.
- Estrogen is synthesized by graafian follicle
- Progesterone is synthesized by corpus luteum
- **Function of Estrogen**
  - Growth of female secondary sex organs,

Tg:- @chanpsiee_notes

- Female secondary sex characters (e.g., high pitch of voice)
- Mammary gland development,
- Also regulate female sexual behaviour

Functions of progesterone

- Supports pregnancy
- Act on mammary gland ⟶ Milk secretion

Hormones of heart, kidney and gastrointestinal tract

Source	Hormone	Action
Heart Atrial wall	Atrial natriuretic factor	Reduces blood pressure
J G cells	Erythropoietin	RBC production
Gastric glands	Gastrin	Stimulates scret^n of HCL and pepsinogen
Duodenum	Secretin	Stimulates secretion of water and bicarbonate ions by Exocrine pancreas
Duodenum	Cholecystokinin	Secretion of pancreatic enzyme from pancreas and bile from gall bladder
Duodenum	Gastric inhibitory peptide (GIP)	Inhibits gastric secretion and motility.

Mechanism of Hormone Action

On the basis chemical nature, hormones can be divided into following groups

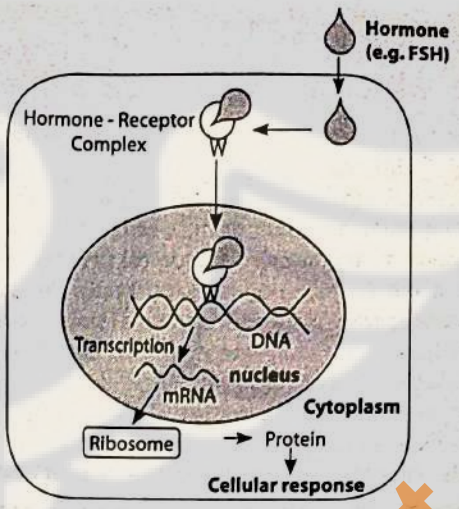
(i) **Peptide, polypeptide, protein hormones** (e.g., insulin, glucagon, pituitary hormones, hypothalamic hormones, etc.)

(ii) **Steroids** (e.g., cortisol, testosterone, oestradiol, progesterone)

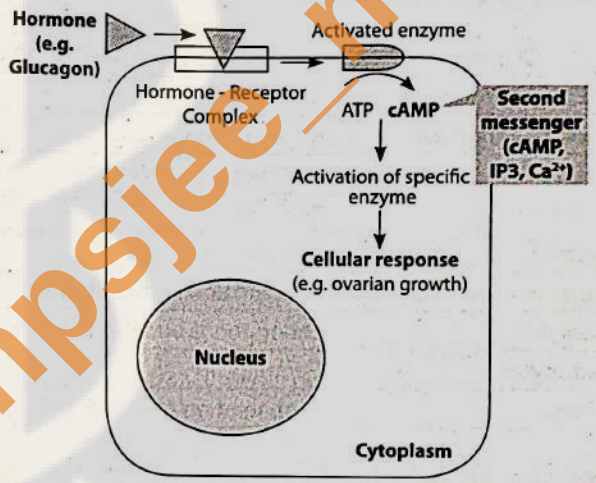
(iii) **iodothyronines** (thyroid hormones)

(iv) **amino-acid derivatives** (e.g., epinephrine)

- Hormones produce their effects on target tissues by binding to specific proteins called hormone receptors
  - Membrane-bound receptors
  - Intracellular receptors (nuclear receptors)
- Each receptor is specific to one hormone only
- Hormones such as **steroid hormones, iodothyronines**, etc. being lipid soluble pass-through cell membrane and interact with intracellular receptors (nuclear receptor) ⟶ regulate gene expression ⟶ forms proteins ⟶ desired effect
- Hormones which interact with membrane-bound receptors normally do not enter the target cell ⟶ generate second messengers **(e.g., cyclic AMP, IP3 , Ca^{++} etc.)** ⟶ regulate cellular metabolism



Action of Steroid Hormone



Action of Protein Hormone

Tg:- @chanpsjee_neet

23. Reproduction In Organism

- The period from birth to the natural death of an organism represents its life span
- Death of every individual organism is a certainty, i.e., no individual is immortal, except single-celled organisms.
- Reproduction is defined as a biological process in which an organism gives rise to young ones (offspring) similar to itself
  - When offspring is produced by a single parent with or without the involvement of gamete formation, the reproduction is **asexual**.
  - When two parents (opposite sex) participate in the reproductive process and also involve fusion of male and female gametes, it is called **sexual reproduction**.

Asexual reproduction

In this method, a single individual (parent) produces offspring
- Offspring are exact copies of their parent
- The term clone is used to describe such morphologically and genetically similar individuals.

Organism	Mode of asexual reproduction
Protists and Monerans	Mitosis
Amoeba, Paramecium	Binary fission
Yeast	Budding
Fungi and algae	Zoospores
Penicillium	Conidia
Hydra	Budding and fragmentation
Sponge	Endogenous bud (Gemmules)
Bryophytes	Gemma cup
Planaria	Regeneration / fragmentation

Vegetative propagules

In plants, the units of vegetative propagation is called vegetative propagules

Vegetative propagules	Plant
Runner	Grass
Stolon	Mint , Jasmine
Tuber (eye)	Potato
Bulbil	Agave
Sucker	Banana
Rhizome	Ginger, Banana, Turmeric
Offset	Eichhornia Crassipes (water hyacinth)
Leaf bud (adventitious bud)	Bryophyllum

Fragmentation

In some organisms, the body breaks into distinct pieces (fragments) each fragment grows into an adult capable of producing offspring (e.g., Hydra).

Water hyacinth

- Most invasive weeds
- Propagate vegetatively at a phenomenal rate and spread all over the water body called as 'terror of Bengal'.

Amoeba

Under unfavourable condition

Amoeba withdraws its pseudopodia and secretes a three-layered hard covering or cyst around itself.

Encystation

→

Under favourable condition

Encysted Amoeba divides multiple fission and produces many minute amoeba or psedopodiospores; Cyst wall burst ⟶ spore liberate.

Sporulation

Sexual reproduction

- Sexual reproduction involves formation of the male and female gametes, either by the same individual or by different individuals of the opposite sex. These gametes fuse to form the zygote which develops to form the new organism
- Offspring are not identical to parents or amongst themselves

Phases of Life

- Animals ⟶ Juvenile Phase ⟶ Reproductive Phase ⟶ Old age ⟶ Death
- Plants ⟶ Vegetative Phase ⟶ Reproductive Phase (Flowering) ⟶ Senescene ⟶ Death

Types	Life cycle
Annual Plants	Completes life cycle in single season / years Annual plants produce fruit once in a life (Monocarpic)
Biennial Plants	Completes life cycle in two years Vegetative phase (one year) ⟶ Reproductive phase (next year) Produce fruit once in a life (Monocarpic)
Perennial Plants	More than two years / seasons of vegetative phase then flower /fruit develops. They can be monocarpic (fruit once in life) or polycarpic (fruit develops more than once in life)

- Annual and biennial plants, show clear cut vegetative, reproductive and senescent phases, but in the perennial species it is very difficult to clearly define these phases
  - bamboo species flower only once in their life time
  - Strobilanthus kunthiana (neelakuranji), flowers once in 12 years.
- In non-primate mammals like cows, sheep, rats, dogs, tiger, etc., cyclical changes in the activities of ovaries and hormones during reproduction are called **oestrus cycle**.
- Whereas, in primates (monkeys, apes, and humans) it is called menstrual cycle.
- Many mammals, especially those living in natural, wild conditions exhibit such cycles only during favorable seasons in their reproductive phase and are therefore called **seasonal breeders**.

Events in sexual reproduction

Pre-fertilisation Events

Gametogenesis

- Gametogenesis refers to the process of formation of the two types of gametes – male and female
  - Homogametes (isogametes) : male and female gametes are similar in appearance e.g., as in some algae
  - Heterogametes : Distinct male (sperm/antherozoid) and female gamete (egg /ovum)

Tg:- @champsjee_neet

Sexuality in organisms

Sexuality in Plants

Monoecious / Bisexual / Homothallic plants

- Both male and female reproductive structures in the same plant
- E.g., Cucurbits, coconuts, Pinus, Pea, Chara, sweet potato (bisexual flower)

Dioecious / Unisexual / heterothallic Plants

- Male and female reproductive structures present in the separate plant
- In flowering plants, the unisexual male flower is staminate, i.e., bearing stamens, while the female is pistillate or bearing pistils
- E.g., Papaya, Date palm, Cycas, Marchantia

Sexuality in animals

Unisexual animals:

- Unisexual animals possess either male or female reproductive organ E.g., Cockroach

Bisexual / hermaphrodite animals:

- Bisexual animals possess both male and female reproductive organs in same individual
- e.g., Earthworms, sponge, tapeworm, leech

Gamete Transfer

- Algae, bryophytes and Pteridophytes: gametes are transferred by water
- In seed plants, pollen grains are the carriers of male gametes

Fertilisation

- Fusion of gametes is called syngamy (Fertilization)
- A form of reproduction in which an egg can develop into an embryo without being fertilized by a sperm is called Parthenogenesis.
- Seen in rotifers, honeybees, some lizards, birds (turkey),

Where does syngamy occur?

External fertilisation

- Syngamy in the external medium (water), i.e., outside the body of the organism is called external fertilisation
- Zygote is formed in the external medium (usually water)
- Seen in most algae, fishes, Amphibians
- Requirement : Synchrony between the sexes and release a large number of gametes into the surrounding medium (water) by both sexes
- Disadvantage : Offspring are extremely vulnerable to predators

Internal fertilisation

- Syngamy occurs inside the body of the organism
- Seen in most fungi, reptiles, birds, mammals, bryophytes, pteridophytes, gymnosperms and angiosperms
- Requirement
  - Motile male gamete and formation of egg is inside female body
  - In these, even though the number of sperms produced is very large, there is a significant reduction in the number of eggs produced
  - In **seed plants**, however, the **non-motile male gametes** are carried to female gamete by pollen tubes

Post-fertilisation Events

- In organisms belonging to fungi and algae, zygote develops a thick wall that is resistant to desiccation and damage ⟶ undergoes a period of rest ⟶ then germinates
- In organisms with haplontic life cycle *zygote divides by meiosis* to form haploid spores that grow into haploid individuals.

Embryogenesis

- Embryogenesis refers to the process of development of embryo from the zygote.
- During embryogenesis, zygote undergoes cell division (mitosis) and cell differentiation [In Haplontic life cycle zygote undergoes meiosis]

Oviparous animals

- Lay fertilized/ unfertilized eggs
- In oviparous animals like reptiles and birds, the fertilised eggs covered by hard calcareous shell are laid in a safe place in the environment;

Viviparous animals

Includes majority of mammals including human beings

Zygote develops into a young one inside the body of the female organism and young ones are delivered out of the body

Flowering plants

- Zygote is formed inside the ovule. After fertilisation the sepals, petals and stamens of the flower wither and fall off. (exception : sepals remain attached in tomatoes, strawberries, raspberries, brinjal, etc.)
- The pistil however, remains attached to the plant
- Post fertilization following changes take place :

  Zygote ⟶ Embryo
  - Zygote develops into embryo
  - Ovule develops into seed
  - Ovary develops into the fruit
- Protective thick wall of ovary is called pericarp

Also note :

Organism	Diploid number
Human beings	46
House fly	12
Fruit fly	8
Maize	20

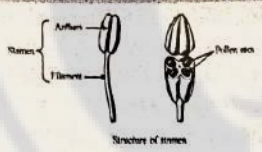
Tg:- @chandsee_neet

24. Sexual Reproduction In Flowering Plants

Male reproductive structure of flower

Stamen

- Stamen has two parts, anther and filament
- Anther is bilobed structure.
- Each lobe has two pollen sac (theca) ⟶ dithecous anther



- The anther is a four-sided (tetragonal) structure consisting of four microsporangia located at the corners, two in each lobe.
- The microsporangia develop further and become pollen sacs.

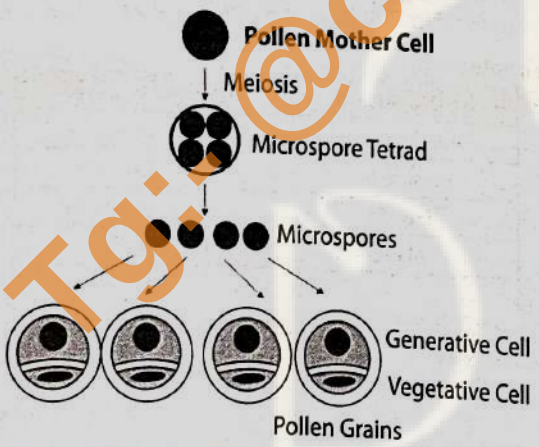
Structure of microsporangium

- It is surrounded by four wall layers epidermis, endothecium, middle layers and the tapetum.

- The outer three wall layers perform the function of protection and help in dehiscence of anther to release the pollen.
- The innermost wall layer is the tapetum. It nourishes the developing pollen grains
- Sporogenous tissue occupies the centre of each microsporangium.

Microsporogenesis

- Cells of the sporogenous tissue undergo meiotic divisions to form microspore tetrads
- Each cell of the sporogenous tissue give rise to a microspore tetrad. Each one is a potential pollen or microspore mother cell. The process of formation of microspores from a pollen mother cell (PMC) through meiosis is called Microsporogenesis
- Microspores formed, are arranged in a cluster of four cells–the microspore tetrad
- Microspores dissociate from each other and develop into pollen grains



Pollen grain

Coverings of Pollen grain

- Hard outer wall is Exine , made up of sporopollenin
  - Sporopollenin is one of the most resistant organic material known.
  - It can withstand high temperatures, strong acids and alkali.
  - No enzyme that degrades sporopollenin is so far known.
  - Pollen grain exine has prominent apertures called germ pores where sporopollenin is absent
- The inner wall of the pollen grain is called the intine made up of cellulose and pectose

Cells inside Pollen grain

- When the pollen grain is mature it contains two cells, the vegetative cell and generative cell
- **Vegetative cell** ⟶ irregular shaped nucleus ⟶ bigger in size , has abundant food reserve
- **Generative cell** ⟶ Spindle shaped ⟶ divides mitotically to give two male gametes on pollination.
- In over 60 per cent of angiosperms, pollen grains are shed at this 2-celled stage.

Generative cell generates male gametes

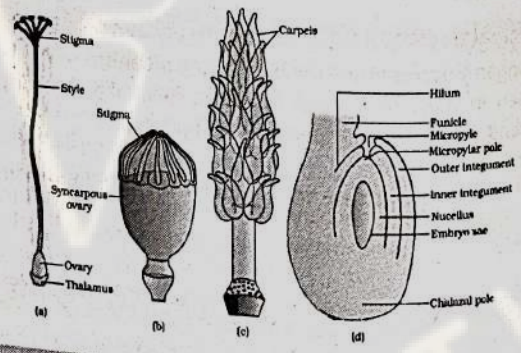
- Pollen grains also causes pollen allergy in some individual
- Used as nutritional supplement by athletes
- Grains of a large number of species can be stored for years in liquid nitrogen (-196°C) : cryopreservation

Female reproductive structure of flower

- The gynoecium represents female reproductive part of flower.
- Gynoecium may consist of a single pistil (monocarpellary) or may have more than one pistil (multicarpellary)
- Multicarpellary Syncarpus : **Papaver**
- Muticarpellary Apocarpus : **Michelia**
- Fused pistil: Syncarpus gynoecium
- Free pistil : Apocarpus gynoecium
- Pistil is composed of Stigma, Style and Ovary
- One ovule in one ovary: **wheat, paddy, mango**
- Many ovules in single ovary: **Papaya, Watermelon, Orchids**

Structure of ovule (megasporangium)

- Placenta connects ovules to ovary through stalk called funicle
- Ovule has hilum, ovule fuses with funicle in region called hilum.
- Each ovule has protective envelopes called integuments.
- Small opening where integuments are absent : Micropyle
- Basal part of ovule, opposite to micropyle : Chalaza
- Most common type of ovule in angiosperm : **anatropous ovule**
- Anatropous ovule is characterized by occurrence of hilum near the micropyle



Megasporogenesis

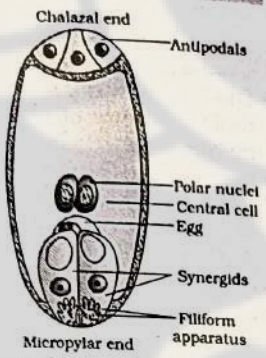
- The process of formation of megaspores from the megaspore mother cell is called Megasporogenesis
- Tissue with abundant reserve food materials ⟶ nucellus
- **One** of the cell of nucellus (2n) particularly archesporial cell in micropylar region differentiate into megaspore mother cell.

Tg:@champsse_neet

- Megaspore mother cell (2n)
  - Location : micropylar end
  - Feature : dense cytoplasm and a prominent nucleus
- It undergoes meiosis form 4 megaspores (n), one of the megaspores is functional while the other three degenerate
- On 3 mitotic divisions, Functional megaspore develops into the female gametophyte (embryo sac) – 7 celled 8 nucleated structure
- This method of embryo sac formation from a single megaspore is termed **monosporic** development

Embryo Sac

- 7 celled 8 nucleated structure
- Egg apparatus
  - Location : micropylar end
  - consists of two synergids and one egg cell
  - Synergids have cellular thickening ⟶ filiform apparatus
  - filiform apparatus guide pollen tubes into the synergid
- Antipodals
  - Location : chalazal end
  - Consist of 3 cell
- Large central cell having two poplar nuclei



Pollination

Transfer of pollen grains to the stigma of a pistil is termed pollination.

Autogamy

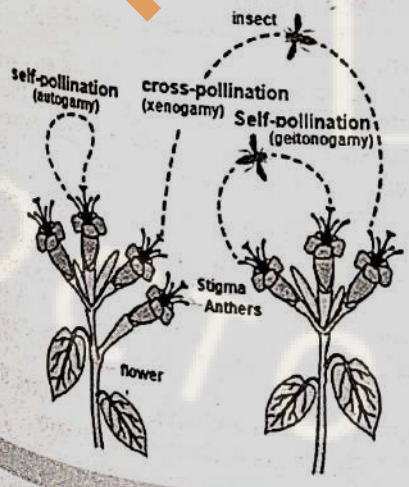
- Transfer of pollen grains from the anther to the stigma of the same flower
- Requires synchrony in pollen release and stigma
- Some plants such as **Viola** (common pansy), **Oxalis** and **Commelina** produce two types of flowers –
  - *Chasmogamous flowers* : similar to flowers of other species with exposed anthers and stigma
  - *Cleistogamous flowers* : do not open at all, cleistogamous flowers are invariably autogamous as there is no chance of cross-pollen landing on the stigma, assures pollination even in the absence of pollinators.

Geitonogamy

- Transfer of pollen grains from the anther to the stigma of another flower of the same plant is called Geitonogamy
- Genetically it is similar to autogamy since the pollen grains come from the same plant.

Xenogamy

- Transfer of pollen grains from anther to the stigma of a different plant.
- Brings genetically different types of pollen grains to the stigma.



Agents of Pollination

Majority of plants use biotic agents (e.g. honeybee) for pollination

Abiotic pollinating agent

Wind Pollination

- Pollination by wind is more common amongst ablotic pollinations
- Requirements for wind pollination
  - Light non sticky pollen
  - Well exposed stamens
- Wind pollinated flowers often have a single ovule in each ovary and numerous flowers packed into an inflorescence; a familiar example is the corn cob
- Common in grasses

Pollination by water

- Seen in algae, bryophytes and pteridophytes.
- Rare in flowering plants, seen mostly in **mocotyledons**
- Shown by **Vallisneria** and **Hydrilla** and sea-grasses such as **Zoster**
- In Vallisneria, pollen grains are released **on the surface** of water
- In sea-grasses such as **Zoster**, pollens are released **inside** water
- In most of the water-pollinated species, pollen grains are protected from wetting by a mucilaginous covering

Both wind and water pollinated flowers are not very colourful and do not produce nectar.

Note : Majority of aquatic plant such as water hyacinth and water lily are pollinated by insect or wind (not by water)

Biotic pollinating agent

- Majority of flowering plants use a range of animals as pollinating agents e.g. Bees, butterflies, flies, beetles, wasps, ants, moths, birds, (lemurs), arboreal (tree-dwelling) rodents, or even reptiles (gecko lizard and garden lizard)
- Insects, particularly bees are the dominant biotic pollinating agents
- Requirement for biotic pollination
  - Large, colourful, fragrant and rich in nectar flowers
  - Secretion of foul odour to attract insect
- Special examples
  - **Amorphophallus** (the flower itself is about 6 feet in height) provide safe places to pollinating agent to lay eggs
  - **Moth and Yucca plant :** cannot complete their life cycles without each other.

Outbreeding Devices

- Continued self-pollination result in **inbreeding depression**, to discourage self-pollination some plants have evolved various mechanisms called as outbreeding devices such as :
  1. Pollen release and stigma receptivity are desynchronised
  2. The anther and stigma are placed at positions unfavourable for self-pollination
  3. self-incompatibility, this is a genetic mechanism and prevents self-pollen (from the same flower or other flowers of the same plant) from fertilising the ovules
  4. Plant is bisexual but flowers are unisexual as seen in **castor, maize** etc it prevents autogamy but not geitonogamy
  5. Flower and plant both are unisexual or Dioceous e.g. **Papaya**, in this plant male and female flowers are present on different plants, This condition prevents both autogamy and geitonogamy

Pollen-pistil Interaction

- The pistil has the ability to recognise the pollen, whether it is of the right type (compatible) or of the wrong type (incompatible), this is a **chemical mediated, dynamic** process
- Pollen grain germinates on the stigma to produce a pollen tube through one of the germ pores.

Tg:- @champions_neet

- Generative cell divides and forms two male gametes
- Pollen tube enters the ovule through the micropyle
- Filiform apparatus guides the entry of pollen tube to synergids

Artificial hybridisation

- This is a method where desired pollen grains are used for pollination and the stigma is protected from contamination (from unwanted pollen). This achieved by emasculation and bagging
- Emasculation: removal of anthers,
- Bagging: covering of flower with a bag made up of butter paper
- Emasculation ⟶ bagging ⟶ bag removed for artificial hybridization ⟶ rebagged ⟶ fruit develops
  - In Bisexual flower : Both emasculation & bagging is done
  - In unisexual flower: no need for emasculation, only bagging is done

Double Fertilisation

- Pollen tube releases two male gametes into the cytoplasm of the synergid.
- One male gamete fuses with egg cell nucleus ⟶ zygote formed
- Another male gamete (n) fuses with central cell (2n) ⟶ k/a triple fusion ⟶ triploid primary endosperm nucleus (3n) forms
- The central cell after triple fusion becomes the primary endosperm cell (PEC) and develops into the endosperm

Post-Fertilisation : Structures and Events

Endosperm

- Endosperm provides nutrition to developing embryo
- Endosperm development precedes embryo development
- PEN undergoes successive nuclear divisions to give rise to free nuclei. This stage of endosperm development is called **free-nuclear endosperm**. Subsequently cell wall formation occurs and the endosperm becomes cellular. This is the most common type of endosperm development.
- Coconut water from tender coconut is nothing but free-nuclear endosperm

Endospermic seed

- Endosperm persist in the mature seed (e.g. wheat, maize, barley, castor and coconut)

Non endospermic seed

- Also k/a non-albuminous or ex-albuminous
- Endosperm is completely consumed by the developing embryo before seed maturation (e.g., pea, groundnut, beans)

Embryo

Zygote divide only after certain amount of endosperm is formed.

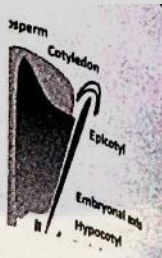
Dicotyledonous embryo

- Consists of an embryonal axis and two cotyledons.
- Epicotyl
  - Portion of embryonal axis above the level of cotyledons is ⟶ epicotyl
  - Terminal part of epicotyl ⟶ Plumule or stem tip.
- Hypocotyl
  - Portion below the level of cotyledons is ⟶ hypocotyl
  - Terminal part of hypocotyl ⟶ radicle or root tip
  - The root tip is covered with a root cap

Monocotyledonous embryo

Embryos of monocotyledons possess only one cotyledon

- Epicotyl
  - The portion above embryonal axis : Epicotyl
  - The terminal part of epicotyl ⟶ Plumule
  - Covering of Plumule ⟶ **coleoptile**

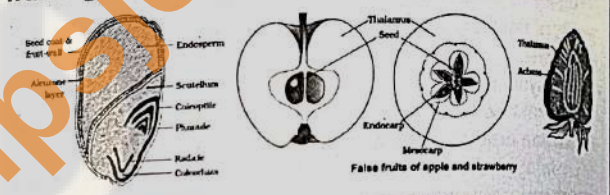


- Hypocotyl
  - The portion below embryonal axis hypocotyl
  - The terminal part of hypocotyl ⟶ radicle and root cap
  - Covering of radicle and root cap ⟶ **coleorhiza**
- In the grass family the cotyledon is called scutellum

Seed

- Small pore in the seed coat is called as **micropyle**, which facilitates entry of oxygen and water into the seed during germination.
- In some seeds nucellus remains persistent k/a **perisperm** as in black pepper and beet
- Wall of the ovary develops into the wall of fruit called pericarp
- Integument ⟶ seed coat, Ovule ⟶ seed
- Fleshy fruits : guava, orange, mango, etc.,
- Dry fruits : groundnut, and mustard etc.
- True fruits (Fruit which develops only from ovary)
- False fruits (fruit develop from ovary + thalamus) : apple, strawberry, cashew, etc.

Generally fruits develops after fertilization, when fruit develop without fertilisation it is called as parthenocarpic fruit E.g. Banana



False fruits of apple and strawberry

Viability of seed

- Viability of seed varies greatly.
- **Lupinus arcticus** excavated from Arctic Tundra, germinated on estimated record of 10,000 years of dormancy
- Seed of date palm **(Phoenix dactylifera)** found viable after 2000 years in dead sea

Fruit with large number of seeds

Orchid and parasitic plants (orobrache and striga) bear fruits with large number of seeds

Apomixis and polyembryony

Apomixis

- Development of fruit without fertilisation ⟶ Parthenocarpy
- Development of seeds without fertilisation ⟶ Apomixis E.g., **Asteraceae and grasses**
- Apomixis is a form of asexual reproduction

Polyembryony

- In some plants **nucellar cells** surrounding the embryo sac protrude into the embryo sac and develop into the embryos, in such species each ovule contains many embryos ⟶ Polyembryony e.g., citrus , mango, orange

Problems with Hybrid seed

- Problem : If the seeds collected from hybrids are sown, the plants in the progeny will **segregate** and do not maintain hybrid characters. Production of hybrid seeds is costly and hence the cost of hybrid seeds becomes too expensive for the farmers.
- Solution : If these hybrids are made into apomicts, there is no segregation of characters in the hybrid progeny.

To- @chanpsee_neet

25. Human Reproduction

Process	Terminology
Formation of gametes	Gametogenesis
Transfer of sperms into the female genital tract	Insemination
Attachment of blastocyst to the uterine wall	Implantation
Embryonic development	Gestation
Delivery of the baby	Parturition

Male Reproductive System

It includes a pair of testes along with accessory ducts, glands and the external genitalia.

Testes

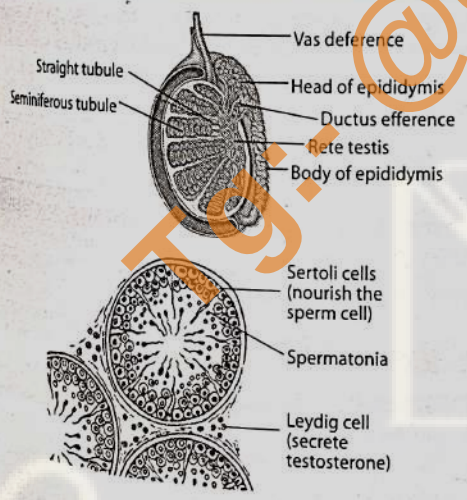
- The testes are situated outside the abdominal cavity within a pouch called scrotum.
- Temperature in scrotum is 2–2.5° C lower than the normal internal body temperature.
- Testes is composed of testicular lobules
- Each lobule contains one to three seminiferous tubules.
- Seminiferous tubule is lined on inner side by
  - Male germ cell (Spermatogonia) : form sperm cells by Spermatogenesis
  - Sertoli cell Provides nutrition to germ cell
- The regions outside the seminiferous tubules called interstitial spaces contain interstitial cells or Leydig cells
  - Leydig cell (interstitial cells) secrete testosterone in response to LH

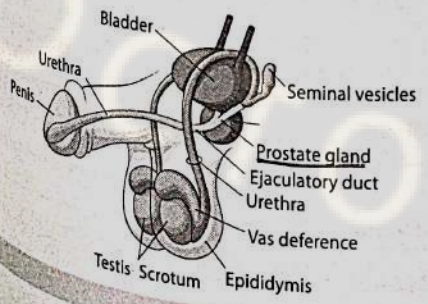
Male sex accessory duct

Seminiferous tubule ⟶ rete testis ⟶ vas (Ductus) efference ⟶ epididymis (maturation of sperms) ⟶ vas deference

Seminal Vesicle ⟶ Ejaculatory duct (store sperms) ⟶ Opens into urethra ⟶ Prostate and Bulbourethral gland opens into urethra

Trick: Sperm StaRts DEEP and takes a Very Dramatic Exit



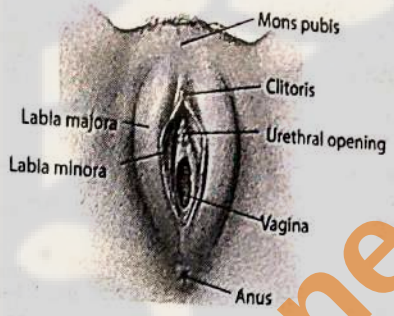


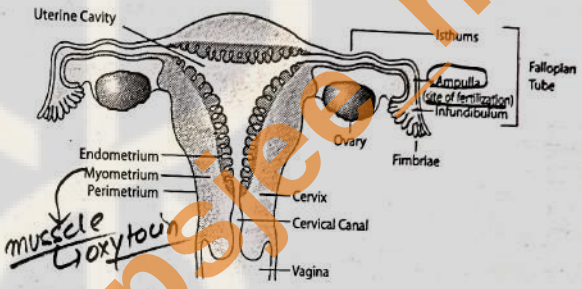
Male sex accessory gland

- Seminal Vesicle (paired) : adds fructose major contributor of semen
- Prostate (single): adds calcium and some enzymes to semen
- Bulbourethral Gland (paired): lubricates urethra

The Female Reproductive System

Ovary ⟶ Fallopian tube ⟶ Uterus ⟶ Cervix ⟶ Vagina





muscle
Oxytocin

Ovary

- Ovary is divided into peripheral cortex and an inner medulla.

Fallopian tube

- Fimbriae (collects ovum from ovary) ⟶ Infundibulum ⟶ Ampulla ⟶ Isthmus

Uterus

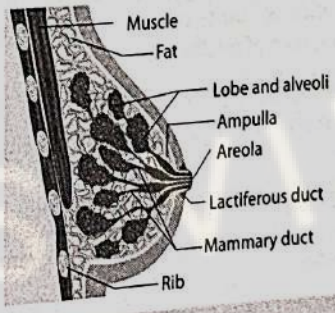
- Ligaments attaches uterus to pelvic wall
- 3 layers perimetrium, myometrium and endometrium
- Endometrium: undergoes cyclical changes in menstrual cycle
- Myometrium: exhibits strong contraction during delivery

Female external genitalia

- Mons Pubis (fatty tissue), Labia majora (outer skin folds), Labia Minora (inner skin folds), clitoris, hymen

Mammary Gland

- Breast is divided into 15-20 mammary lobes
- Mammary lobes contain alveoli
- Cells of alveoli secrete milk
- Alveoli ⟶ mammary duct ⟶ lactiferous duct
- Prolactin : increases milk production
- Oxytocin : milk ejection



Tg:- @champstee_neet

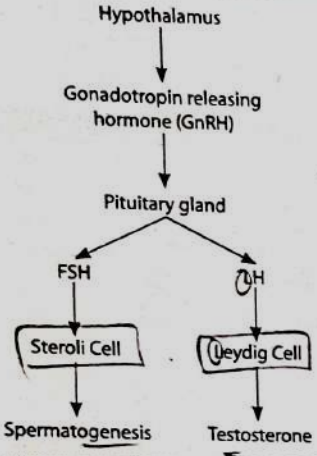
Spermatogenesis

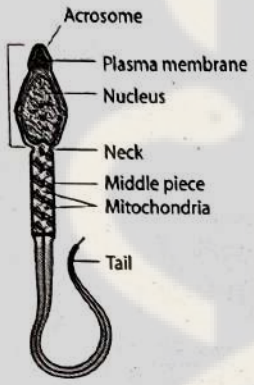
Spermatogenesis

Male germ cell (spermatogonia) multiplies by mitotic division and increase in numbers. Some of the spermatogonia called primary spermatocytes periodically undergo meiosis.

Primary spermatocytes (46) $\xrightarrow{\text{Meiosis I}}$ Secondary spermatocytes (23) $\xrightarrow{\text{Meiosis II}}$ Spermatids $\xrightarrow{\text{Spermiogenesis}}$ Spermatozoa (sperms) $\xrightarrow{\text{Spermiation}}$ Release of sperm from Sertoli cell into semi tubule

Hormones involved in spermatogenesis





Structure of a sperm

Head	• Head contains haploid nucleus, • Anterior portion is covered by a cap-like structure called acrosome. • Acrosome is derived from Golgi apparatus and is filled with enzymes that help in fertilisation
Middle piece	Possess mitochondria
Tail	• Sperm motility

Semen

- The seminal plasma along with the sperms constitute the semen
- The human male ejaculates about 200 to 300 million sperms
- at least 60 per cent sperms must have normal shape and size and at least 40 percent of them must show vigorous motility

Oogenesis

- Oogenesis starts during embryonic development
- Female germ cells (oogonia) are formed within ovary
- No more oogonia are formed and added after birth
- Oogonia differentiate to form Primary oocyte (2n)
- The primary oocytes (2n) enter the first meiotic division and remain in the diplotene stage of prophase I for an extended period. The division gets arrested at this stage and only resumes at the time of ovulation.

Primary follicle

- Primary oocyte surrounded by granulosa cells k/a primary follicle.

Secondary follicle

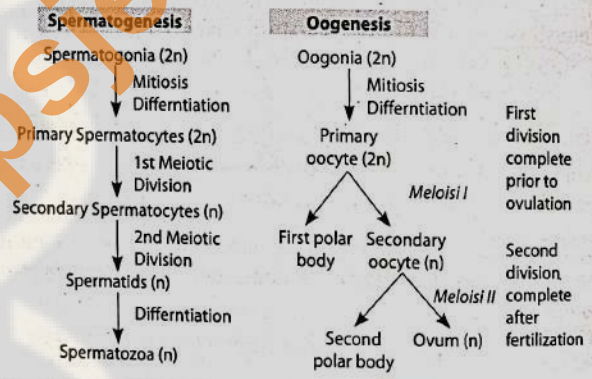
- Primary follicle gets surrounded by more granulosa cell k/a secondary follicle.

Tertiary Follicle

- Secondary follicle develops antrum k/a tertiary follicle
- Primary oocyte completes its first meiotic division (gets arrested in metaphase II) in tertiary follicle

Graafian follicle

- The tertiary follicle further changes into the mature follicle or Graafian follicle. The secondary oocyte forms a new membrane called **zona pellucida** surrounding it
- Graafian follicle ruptures to release ovum (ovulation)



Event	Female gamete stage
During intrauterine life	Oogonia forms, no more oogonia are added after birth
At the time of birth	Primary oocyte arrested at prophase I
At the time of ovulation	Secondary oocyte arrested at metaphase II
On fertilization	Ovum

Menstrual Cycle

Follicular Phase	
Duration	6 - 13 Days
Main Hormone	Estrogen, FSH, LH
Changes	Ovary : Development of Graafian follicle Uterus : Uterine gland proliferation

Ovulatory Phase	
Duration	14th Day
Main Hormone	LH
Changes	Ovary : Ovulation

Tg: @chnnpsjee_neet

Luteal Phase (Secretory Phase)	
Duration	15th to 28th Day
Main Hormone	Progesterone
Changes	Ovary : corpus luteum formation Uterus : becomes secretory

Menstrual Phase	
Duration	First 1-5 days
Main Hormone	Drop progesterone
Changes	40 ml blood is lost

Corpus luteum

- After ovulation, Graafian follicle transform as the corpus luteum
- It secretes progesterone ⟶ maintenance of the endometrium
- In absence of fertilisation
- corpus luteum ⟶ degenerates ⟶ Endometrium disintegrates ⟶ menstruation

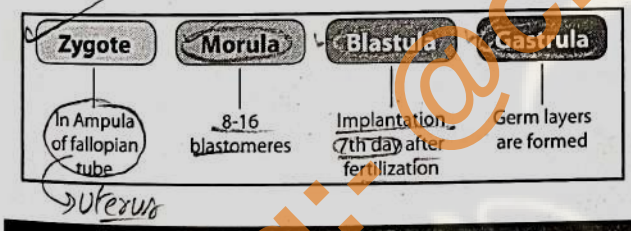
✓ The first menstruation begins at puberty and is called menarche

✓ Menstrual cycles cease around 50 years of age k/a menopause.

Fertilization

- Fertilization takes place in the ampullary region / junction of the isthmus and ampulla of fallopian tube
- During fertilisation, a sperm comes in contact with the zona pellucida layer of the ovum and induces changes in the membrane that block the entry of additional sperms
- This induces the completion of the meiotic division of the secondary oocyte

Implantation



Pregnancy and embryonic development

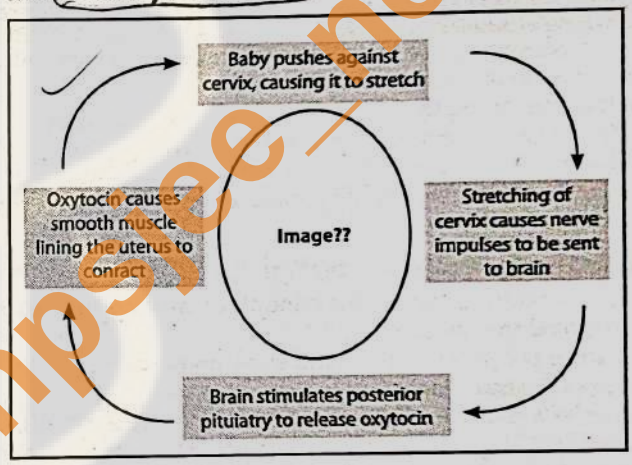
- After implantation, finger-like projections appear on the trophoblast called chorionic villi
- Chorionic villi and uterine tissue jointly form placenta
- Placenta
  - Placenta facilitate the supply of nutrients to the embryo
  - The placenta is connected to embryo by an umbilical cord
  - Placenta produces human chorionic gonadotropin (hCG), human Placental lactogen (hPL), estrogens, progestogens,
- Ovary secrete hormone relaxin during pregnancy
- Hormones produced only during pregnancy: **hCG, hPL, relaxin**
- **Hormones increase during pregnancy:** Estrogen, progestogens, cortisol, prolactin, thyroxine, etc.
- Immediately after implantation, the inner cell mass (embryo) differentiates into ectoderm, endoderm and mesoderm

Foetal development

End of 1st month	Foetal Heart sound is heard
End of 2nd month	foetus develops limbs and digits
End of 3rd months	limbs and external genital organs developed
5th month	foetal movement observed, development of hairs
6th month	eye-lids separate, and eyelashes are formed
9th month	foetus fully developed

Parturition and lactation

- Process of delivery of the foetus (childbirth) is called parturition
- Hormones involved in parturition : cortisol, oestrogens and oxytocin
- The signals for parturition originate from the fully developed foetus and the placenta which induce mild uterine contractions called foetal ejection reflex



The milk produced during the initial few days of lactation is called colostrum which contains several antibodies (IgA antibody) absolutely essential to develop resistance for the new-born babies.

Tg:-@chanpsee_neet

Fertilization → IUD → Implantation

26. Reproductive Health

According to the World Health Organisation (WHO), reproductive health means a total well-being in all aspects of reproduction, i.e., physical, emotional, behavioural and social.

Reproductive health problems and strategies

India was first country in world to initiate "Family Planning programme" (1951). This program is Currently operational as **Reproductive and Child Health Care (RCH)** programmes'

Amniocentesis

- In amniocentesis some of the amniotic fluid of the developing foetus is taken to analyse the fetal cells and dissolved substances.
- This procedure is used to test for the presence of certain genetic disorders such as down syndrome, haemoplilia, sickle-cell anemia, etc., determine the survivability of the foetus.
- This test was used for foetal sex determination hence now banned in India

Population stabilisation and birth control

Contraceptives are the techniques to prevent pregnancy as a consequence of sexual intercourse.

An ideal contraceptive should be :

- user-friendly, easily available, effective
- reversible with no or least side-effects.
- Should not interfere with the sexual drive, desire and/or the sexual act of the user.

Natural methods of contraception

- Natural methods work on the principle of avoiding chances of ovum and sperms meeting.
- Chances of failure is high in natural methods

1) Periodic abstinence

- Couples avoid or abstain from coitus during fertile period i.e., from day 10 to 17th day of the menstrual cycle when ovulation could be expected

2) Withdrawal or coitus interruptus

- Male partner withdraws his penis from the vagina just before ejaculation so as to avoid insemination

3) Lactational amenorrhea

- Ovulation and therefore the cycle do not occur during the period of intense lactation following parturition. Therefore, as long as the mother breast-feeds the child fully, chances of conception are almost nil
- Effective only up to a maximum period of six months following parturition.

Barrier methods of contraception

In barrier methods, ovum and sperms are prevented from physically meeting with the help of barriers.

1) Condoms

- Made for both male and female
- Made of thin rubber/ latex sheath, cover the penis in the male or vagina and cervix in the female, so that the ejaculated semen would not enter into the female reproductive tract
- Additional Benefits: protect the user from STIs and AIDS
- Nirodh is a popular brand of condom for the male.

2) Diaphragms, cervical caps and vaults

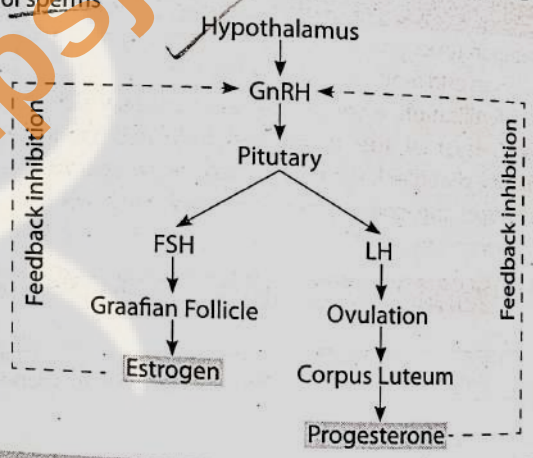
- Made for only female, Reusable, self inserted
- Use spermicidal creams, jellies to increase their contraceptive efficiency.

3) Intra Uterine Devices (IUDs)

- These devices are inserted by doctors or expert nurses in the uterus through vagina.
- Types of IUD
  - Non-medicated IUDs (e.g., Lippes loop)
  - Copper releasing IUDs (CuT, Cu7, Multiload 375)
  - hormone releasing IUDs (Progestasert, LNG-20)
- Mechanism of action
  - IUDs increase phagocytosis of sperms
  - Cu ions suppress sperm motility and its fertilising capacity
  - Hormone releasing IUDs, in addition, make the uterus unsuitable for implantation and cervix hostile to the sperms.
- Suitable for women who wants to delay pregnancy/ space children

Oral contraceptive Pills

- Types
  - Progestogen Pill
  - Progestogen – Estrogen combination pill
- Pills have to be taken daily for a period of 21 days starting preferably within the first five days of menstrual cycle. After a gap of 7 days (during which menstruation occurs) it has to be repeated in the same pattern till the female desires to prevent conception
- Mechanism of action
  - They inhibit ovulation
  - inhibit implantation
  - alter the quality of cervical mucus to prevent/retard entry of sperms



Saheli

- Non-steroidal (Estrogen antagonist)
- Once a week pill
- Few side effect, high contraceptive value
- Developed by Central Drug Research Institute (CDRI) in Lucknow, India

Implants under the skin

- Progestogens alone or in combination with estrogen can also be used by females as injections or implants under the skin
- Mode of action is similar to that of pills
- Effective periods are much longer.

Emergency contraceptives

Measures that can be used as emergency contraceptive

1) Progestogens pill
2) Progestogen-Estrogen pill
3) IUDs

] Use within 72 hours of coitus

Side effects of contraceptive methods

- Nausea, abdominal pain, breakthrough bleeding,
- irregular menstrual bleeding or even **breast cancer** etc.

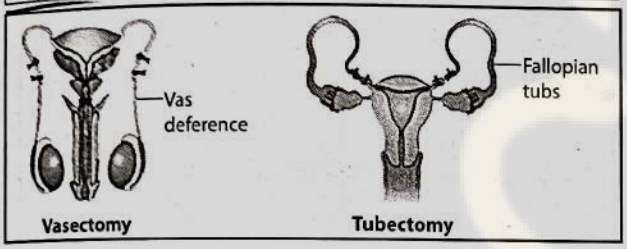
Tg - @chanpsjee_neet

Sterilisation

Surgical methods, also called sterilisation, are generally advised for the male/female partner as a terminal method to prevent any more pregnancies.

- Sterilisation procedure in the male is called 'vasectomy' and that in the female, 'tubectomy"
- Surgical intervention blocks gamete transport and thereby prevent conception

Vasectomy	Tubectomy
Performed in male	Performed in female
In vasectomy, a small part of the vas deferens is removed or tied up through a small incision on the scrotum (semen without sperm)	In tubectomy, a small part of the falloplan tube is removed or tied up through a small incision in the abdomen or through vagina
These techniques are highly effective but their reversibility is very poor.	



Medical termination of pregnancy (MTP)

MTP	Intentional or voluntary **termination of pregnancy** before full term is called medical termination of pregnancy or induced abortion
Year of Implementation	Government of India legalized MTP in 1971
Grounds for MTP	- The continuation of the pregnancy would involve a risk to the life, physical. metal health of the pregnant woman - Risk to the child – physical, mental abnormality, chance of handicapped
Rule	
first 12 weeks of pregnancy (First Trimester)	MTP is safe MTP can be done on the opinion of one registered medical practitioner
> 12 weeks but < 24 weeks of pregnancy (second trimester)	MTP is riskier Requires opinion of two registered medical practitioners
Misuse	Amniocentesis is done to detect sex of child, if female child is found—MTP is performed

Sexually transmitted infections (STIs)

- Infections or diseases which are transmitted through sexual intercourse are collectively called sexually transmitted infections (STI) or venereal diseases (VD) or reproductive tract infections (RTI).
- Common STIs: **Gonorrhea, syphilis, genital herpes, chlamydiasis, genital warts, trichomoniasis, hepatitis-B**
- Except for hepatitis-B, genital herpes and HIV infections, other diseases are completely curable if detected early and treated properly.
- Complication of STI: pelvic inflammatory diseases (PID), abortions, still births, ectopic pregnancies, infertility or even cancer of the reproductive tract.

Infertility

- Inability to conceive or produce children even after 2 years of unprotected sexual cohabitation is called infertility.
- The couples could be assisted to have children through certain special techniques commonly known as assisted reproductive technologies (ART).

In vitro fertilization (IVF), Test Tube baby programme

Ova from female and sperms from the male are collected

↓

Ova and sperm are included to form Zygote in laboratory

(In vitro fertilization also k/a Test tube baby programe : fertilisation is done outside the body)

Zygote is formed

- Zygote or early embryo → Transferred into the falloiantube → The procedure is called (ZIFT - Zygote intra fallopian transfer)
- Zygote with more than 8 blastomrere (morula) → Transferred into the Uterus → The procedure is called IUT - intra uterine transfer

Note : IVF technique is used only when a blockage is present in a woman's fallopian tube which prevents natural fertilization of sperm and ovum

Embryos formed by in-vivo fertilisation (fusion of gametes within the female) also could be used for such transfer to assist those females who cannot conceive

GIFT – gamete intra fallopian transfer

- Advised to women who cannot produce gamete (ovum)
- Ovum is collected from a donor , transferred into the fallopian tube of another female who cannot produce one, but can provide suitable environment for fertilisation.

ICSI - Intra cytoplasmic sperm injection

- a sperm is directly injected into the ovum

Artificial insemination (AI)

- In this technique, the semen collected either from the husband or a healthy donor is artificially introduced either into the vagina.
- AI is used in cases where Male partner is unable to inseminate the female or have a very low sperm counts in the ejaculate
- Artificial insemination into the uterus is called as **intra-uterine Insemination (IUI)**

Condition	Treatment advised
Women with blocked fallopian tube	IVF (Test Tube baby Programme)
Women cannot produce ovum	GIFT – gamete intra fallopian transfer
Male partner has low sperm count	artificial insemination (AI)

Tg:- @chandjee_neet

27. Principles of Inheritance and Variations

Introduction

- Inheritance is the process by which characters are passed on from parent to progeny; it is the basis of heredity.
- Variation is the degree by which progeny differ from their parents
- Causes of variation : Sexual reproduction (recombination), mutation
- Sahiwal cows in Punjab is developed through artificial selection and domestication

Mendel's laws of inheritance

- Mendel performed hybridization experiment (1856 – 1863)
- Pea plant — Larger sample size — confirmed his inferences on successive generations
- Mendel used true breeding lines
- A true breeding line is one that, having undergone continuous self-pollination, shows the stable trait inheritance and expression for several generations.
- He used statistical and mathematical logic, used large sample size
- Mendel used 7 contrasting character, 14 true breeding plants varieties

S. No.	Characters	Constrasting Traits
1.	Stem height	Tall / dwarf
2.	Flower colour	Violet / white
3.	Flower position	Axial / terminal
4.	Pod shape	Inflated / constricted
5.	Pod colour	Green / yellow
6.	Seed shape	Round / wrinkled
7.	Seed colour	Yellow / green

Inheritance of one gene

- Mendel called gene as Factors
- Described factors as Stable and discrete units of inheritance
- Genes which code for a pair of contrasting traits are known as alleles, i.e., they are slightly different forms of the same gene
- TT or tt : Pair of identical allele ⟶ Homozygous
- Tt : Pair of non-identical allele ⟶ Heterozygous (Monohybrid Plant)

Laws of Mendel

- Based on his observations on monohybrid crosses, Mendel proposed two general rules
  - Law of dominance
  - Law of Segregation

Law of dominance

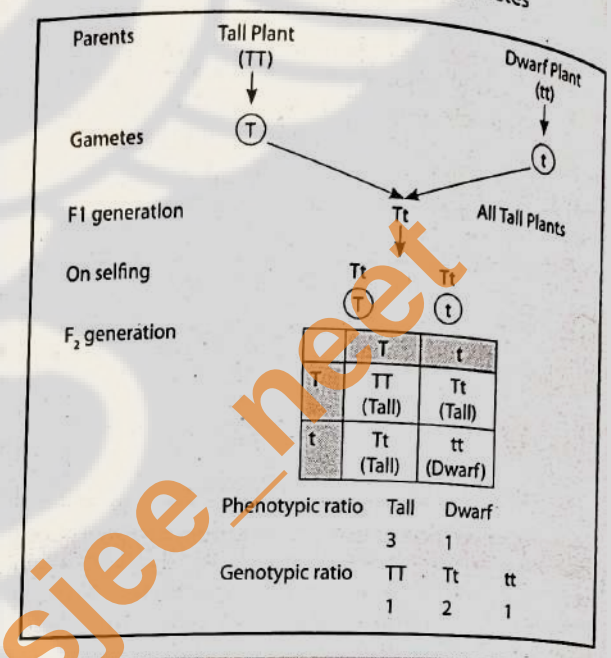
(i) Characters are controlled by discrete units called factors.
(ii) Factors occur in pairs.
(iii) In a dissimilar pair of factors one member of the pair dominates (dominant) the other (recessive).
(iv) F1 always resembled either one of the parents

Note : The recessive characters are only expressed in homozygous conditions

In a monohybrid cross, law of dominance explains
a) expression of only one of the parental characters in the F1
b) expression of both characters in the F2
c) explains the proportion of 3:1 obtained at the F2

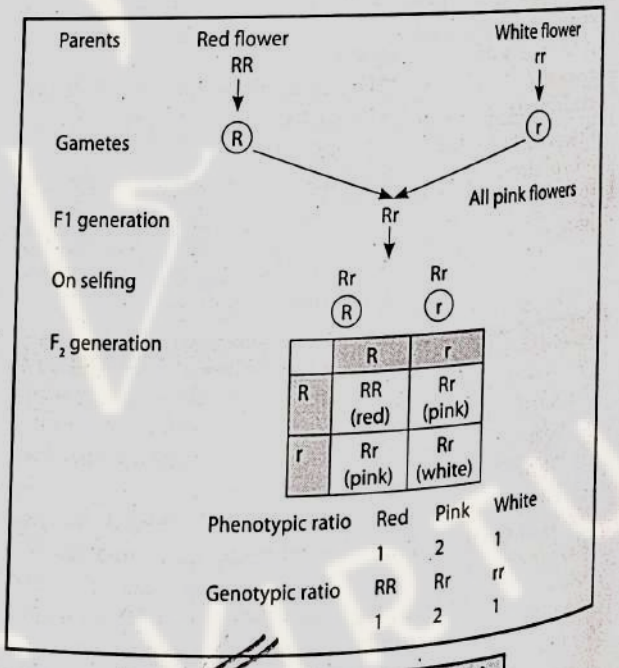
Law of segregation of allele

- Mendel also observed that recessive parental trait is expressed without any blending in the F2 : law of segregation of alleles Law of purity of gamete
- Characters segregate while formation of gametes



Incomplete Dominance

1) When experiments on peas were repeated on dog flower (Snapdragon or Antirrhinum sp.), it was found that sometimes the F1 had a phenotype that did not resemble either of the two parents and was in between the two.
2) Another example of incomplete dominance is starch grain size
BB : Round large seeds bb: small wrinkled seeds
Bb : Round seed intermediate size (incomplete dominance)

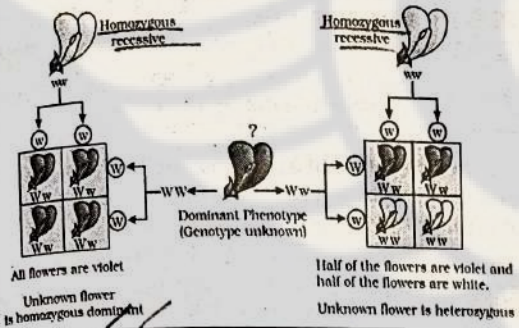


Genotypic ratio = Phenotypic ratio (1 : 2 : 1) = (1 : 2 : 1)

Tg:-@chanpsjee_neet

Test Cross

- To determine the genotype of a tall plant at F2 , Mendel crossed the tall plant from F2 with a dwarf plant (recessive parent) called as a test cross



Genotypic ratio = Phenotypic ratio
(1 : 1) = (1 : 1)

Co-dominance

- In case of co-dominance the F1 generation resembles both parents
- ABO blood groups are controlled by the gene I
- ABO blood grouping shows **multiple allele** in population
- The gene (I) has three alleles i^A , i^B and i^O
- $i^A = i^B > i^O$
- When I^A and I^B are present together (AB Blood group)they both express their own Types of sugars : called as codominance
- There are six different combinations of these three alleles that are possible
- Example of codominance: AB blood group

Allel from Parent 1	Allel from Parent 2	Genotype of offspring	Blood types of offspring
I^A	I^A	I^AI^A	A
I^A	I^B	I^AI^B	AB
I^A	i	I^Ai	A
I^B	I^A	I^AI^B	AB
I^B	I^B	I^BI^B	B
I^B	i	I^Bi	B
i	i	ii	O

Note : Dominance is not an autonomous feature of a gene because It depends as much on the gene product and the production of a particular phenotype from this product.

Inheritance of two genes

- Mendel performed dihybrid cross where he crossed pea plants that differed in two characters
- Seeds with yellow color and round shape crossed with seeds of green color and wrinkled shape
- The yellow and green color segregated in a 3:1 ratio. Round and wrinkled seed shape also segregated in a 3:1 ratio; just like in a monohybrid cross
- Punnet square concept given by British geneticist, Reginald C. Punnett

	RY	Ry	rY	ry
RY	RRYY	RRYy	RrYY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

Round, yellow : 9
Round, green : 3
wrinkled, yellow : 3
wrinkled, green : 1

9:3:3:1phenotypic ratio

Law of Independent Assortment

- Based on observations on dihybrid crosses
- The law states that 'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters'
- It means factors independently assort and combine in all permutations and combinations
- Mendel's law of independent assortment does not hold true for the linked genes that were located on the same chromosomes

Mendel's work remains unrecognised till 1900, why?

Mendel published his work: 1865

1. Communication was not easy those days
2. Mendel said Genes (factors) are stable and discrete unit
3. The pair of alleles which did not 'blend' with each other: this Idea was not accepted by majority as continuous variation seen in nature
4. He used mathematics in biology: many did not like this idea
5. Mendel could not provide any physical proof for the existence of factors

In 1900, three Scientists (**de Vries, Correns and von Tschermak**) independently rediscovered Mendel's results on the inheritance of characters

Chromosomal Theory of Inheritance

Chromosomal theory of inheritance

- Given by Sutton and Bovary
- This theory states chromosomes are the carriers of genes
- It correctly explains the mechanism underlying the laws of Mendelian inheritance by identifying chromosomes with the paired factors (particles) required by Mendel's laws

Experimental verification of the chromosomal theory of inheritance is given by **Thomas Hunt Morgan**

Morgan worked with Drosophila melanogaster, why?

1) Could be grown on simple medium in the laboratory.
2) Complete their life cycle in about two weeks,
3) Single mating could produce a large number of progeny flies
4) Clear differentiation of the sexes
5) Variations that can be seen easily with microscope

Linkage and Recombination

- When Morgan performed dihybrid cross, his F2 ratio deviated very significantly from the 9:3:3:1
- He observed that the two genes did not segregate independently of each other
- Morgan attributed this due to the physical association or linkage of the two genes and coined the term linkage to describe this physical association of genes on a chromosome
- Tightly linked genes - showed very low recombination
- Loosely linked genes - showed higher recombination
- Alfred Sturtevant used the frequency of recombination between gene pairs on the same chromosome as a measure of the distance between genes and mapped their position on the chromosome

Plotron

Polygenic inheritance

- Mendel described traits as having distinct form e.g. Tall and Dwarf
- But there are many traits which are not so distinct in their occurrence and are spread across a gradient. E.g. Height, Skin color. Continuous variation is seen in such trait
- Such traits are generally controlled by three or more genes and are thus called as polygenic traits

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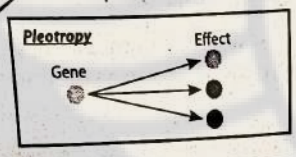
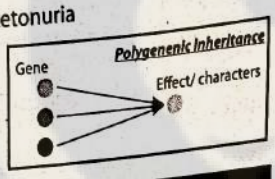
Pleiotropy

- In general one gene control a single phenotype or trait
- But in some instances, a single gene can exhibit multiple phenotypic expressions; Such a gene is called a pleiotropic gene
- An example of this is : phenylketonuria





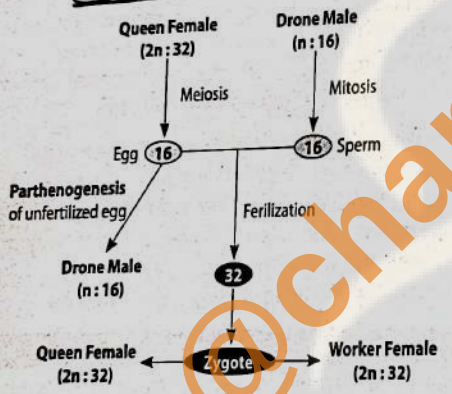
Sex Determination

XY Type of Sex determination	XO Type of Sex determination	ZW Type of Sex determination
Male is heterogamous	Male is heterogamous	Female is heterogamous
Male (X, Y), Female (X, X)	Male (X, O), Female (X, X)	Male (Z, Z), Female (Z, W)
Humans Drosophila	Insects	Birds (Chicken)

➤ **Henking discovered the X chromosome in 1891.**

Sex Determination in Honey Bee

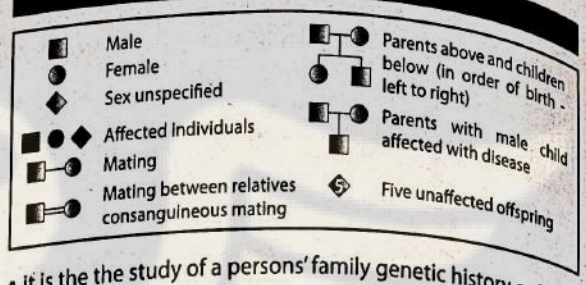
- In Honeybee male or female sex is determined by the number of sets of chromosomes an individual receives.
- Males (n=16) are haploid and females (2n=32) are diploid, this is called as *haplo diploid sex-determination*



Mutations

Definition	Mutation is a phenomenon which results in alteration of DNA sequences due to Loss (deletions) or gain (insertion/duplication) of a segment of DNA
Effect	Mutation result in chromosomal abnormalities or aberrations Chromosomal aberrations are commonly observed in cancer cells
Types	**Point mutation :** Mutation due to change in a single base pair of DNA is known as point mutation e.g., sickle cell anemia **Frame shift mutation :** Deletions and insertions of base pairs of DNA, causes frame-shift mutations
Mechanism	Many chemical and physical factors induce mutations called as mutagens e.g., UV radiations

Pedigree analysis



- It is the the study of a persons' family genetic history or family tree
- it is made up of symbols and lines
- used to trace Mendelian disorders in a family

Mendelian Disorders

- The disorders that are transmitted to the offspring as per Mendelian principles of inheritance are called Mendelian disorders
- X linked recessive : Haemophilia, Colour blindness
- Autosomal recessive: Cystic fibrosis, Sickle cell anaemia, Phenylketonuria, Thalassemia etc.
- Autosomal dominant : myotonic dystrophy

Colour Blindness

- X linked recessive disorder
- Affected individual fail to discriminate between red and green colour
- Color blindness affect more commonly to males because genes that lead to red-green colour blindness are on the X chromosome. Males have only one X chromosome and females have two

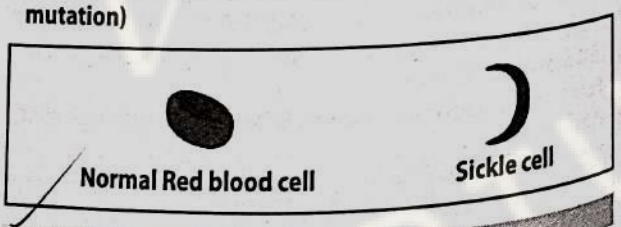
Haemophilia

- X linked recessive disorder
- Protein involved in clotting of blood is affected ⟶ simple cut result in non stop bleeding
- The possibility of a female becoming a haemophilic is extremely rare because mother of such a female has to be at least carrier and the father should be haemophilic (unviable in the later stage of life).

Sickle cell anemia

- Autosomal recessive disorder, Chr. 11
  - $Hb^A Hb^A$ ⟶ Normal Haemoglobin
  - $Hb^A Hb^S$ ⟶ Carrier of a disease
  - $Hb^S Hb^S$ ⟶ Sickle cell anaemia

- Caused by substitution of Glutamic acid (Glu) by Valine (Val) at the sixth position of the beta globin chain of the haemoglobin molecule
- This results due to the single base substitution at the sixth codon of the beta globin gene from GAG to GUG **(Point mutation)**



Phenylketonuria

- Autosomal recessive trait
- Affected individual lacks an enzyme that converts the amino acid phenylalanine into tyrosine.
- Here Single gene can exhibit multiple phenotypic expressions, this is an example of pleiotropy

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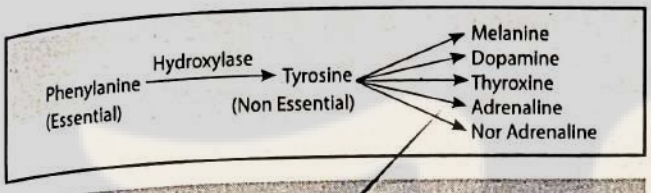
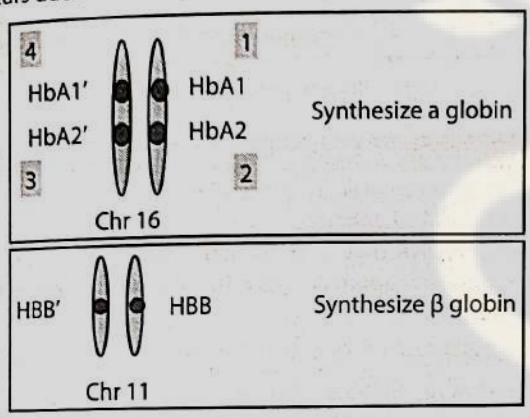


Thalassemia

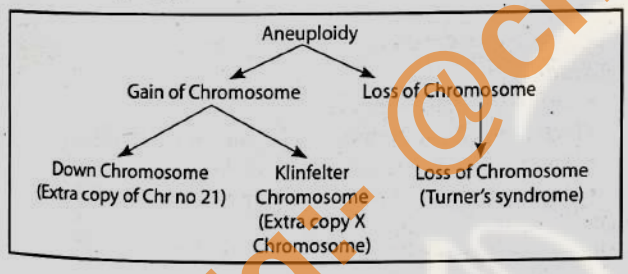
- Autosomal recessive blood disease
- Chr no 16 : 4 allele (2 genes HBA1 and HBA2) involve in synthesis of α globin
- Chr no 11 : 2 allele (single gene HBB) synthesize β globin
- In α Thalassemia, production of α globin chain is affected while in β Thalassemia, production of β globin chain is affected
- Occurs due deletion mutation



- Thalassemia : quantity of RBC is less
- In sickle cell anaemia : quality of RBC is defective

Chromosomal Disorders

- Chromosomal disorders are caused due to absence or excess or abnormal arrangement of one or more chromosomes.
- Failure of segregation of chromatids (anaphase) during cell division cycle results in the gain or loss of a chromosome(s), called aneuploidy.



- Failure of cytokinesis after telophase stage of cell division results in an increase in a whole set of chromosomes in an organism, this phenomenon is known as **polyploidy**

Down's Syndrome

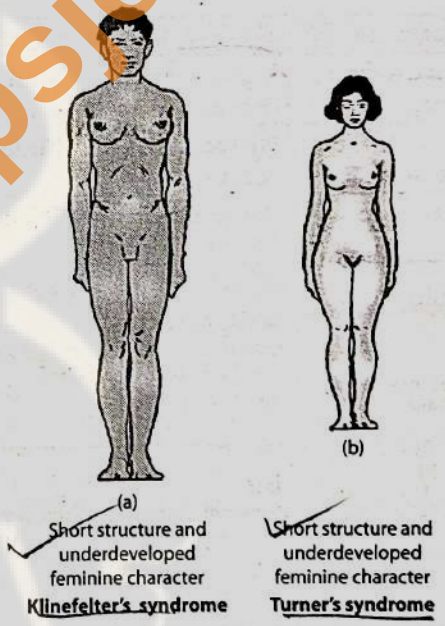
- Presence of an additional copy of the chromosome number 21 (trisomy of 21)
- The affected individual is short statured with small round head, furrowed tongue
- Palm is broad with characteristic palm crease

Klinefelter's Syndrome

- Caused due to the presence of an additional copy of X chromosome resulting into a **karyotype** of 47, XXY
- Masculine with feminine development (development of breast, i.e., Gynaecomastia)
- Such individual is sterile

Turner's syndrome:

- Caused due to the absence of one of the X chromosomes, 45X0
- Sterile female, lack secondary sexual characters



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28. Molecular Basis of Inheritance

- Role of DNA
  - acts as the genetic material in most of the organisms.
- Role of RNA
  - acts as a genetic material in some viruses
  - acts as messenger (mRNA)
  - adapter molecule (tRNA)
  - structural and catalytic molecule (snRNA)

DNA Structure

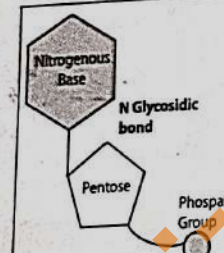
- DNA is a long polymer of deoxyribonucleotides
- Number of base pairs in various organism :

Bacteriophage (φ ×174)	5386 nucleotides
Bacteriophage lambda	48502 base pairs (bp)
Escherichia coli	4.6×10^6 bp
Haploid human DNA	3.3×10^9 bp 2002

Structure of Polynucleotide Chain

- A nucleotide has three components – a nitrogenous base, a pentose sugar and a phosphate group
- Nitrogenous bases –
  - Purines (Adenine and Guanine),
  - Pyrimidine (Cytosine, Uracil and Thymine).
- Bonds

Bond between	Type of bond	Result
Nitrogenous base and 1' C pentose sugar	N-glycosidic linkage	Nucleoside
Phosphate group and 5' C of a nucleoside	Phospoester linkage	Nucleotide
Bond between two nucleotides	Phosphodiester linkage	Dinucleotide



Pentose sugar + Nitrogen base Nucleoside
Nucleoside + Phosphate group Nucleotide
5' end = free phosphate group
3' end = free OH group

RNA
Sugar: Ribose sugar (- OH group at 2' C)
Uracil in place of thiamine (5 Methyl Uracil)

- RNA
  - Sugar: Ribose sugar (- OH group at 2' C)
  - Uracil in place of thiamine (5 Methyl Uracil)

Scientist involved

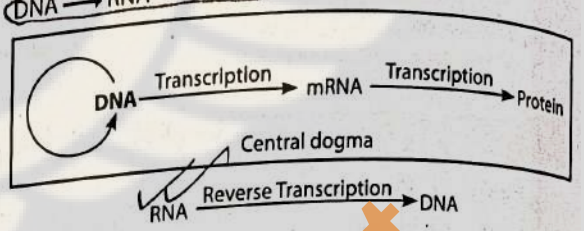
Friedrich Meischer	DNA is an acidic substance in nucleus, called is as nuclein
Wilkin & Franklin	Used X ray diffraction tech to study DNA
Erwin Chargaff	Nitrogen base pairing rule
Watson and Crick	Proposed DNA Double Helix mode

Features of the Double-helix structure of DNA

- Made up of two polynucleotide chains
- Two chains have anti-parallel polarity
- Hydrogen bonds A=T, G ≡ C
- Right-handed helix,
- The pitch of the helix is 3.4 nm
- Distance between a bp is 0.34 nm

Central Dogma by Francis Crick

- Central dogma was proposed by Francis Crick
- Central dogma states that the genetic information flows from DNA → RNA → Protein



Packaging of DNA Helix

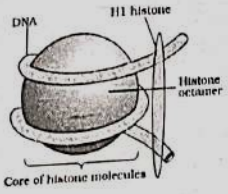
- Diploid human DNA : 6.6×10^9 bp
- Length of DNA : 2.2 meters
- A length of DNA that is far greater than the dimension of a typical nucleus (approximately 10^{-6} m) hence packaging of DNA is required

Prokaryotes

- Prokaryotes do not have nucleus
- Negatively charged DNA is contained in Nucleoid
- DNA is organised as large loops held by non-histone proteins

Eukaryotes

- The negatively charged DNA is wrapped around the positively charged histone



- **Histone**
  - Positively charged protein
  - Rich in the basic amino acids lysine and arginine
  - Histone protein are organised as Histone Octamer
  - AIIMS H1 histone is not a part of **Histone octamer**
- DNA + Histone = **Nucleosome**
- Nucleosome contains ~ 200 bp of DNA helix
- Repeating unit of nucleosome constitutes Chromatin
- Nucleosome in chromatin are seen as 'beads-on-string'
- Chromatin condensed to form Chromatic fibre which further condensed in **Metaphase**
- The packaging of chromatin at higher level requires additional set of proteins → Non-histone Chromosomal (NHC) proteins

Loosely packed chromatin	→ Stains light	→ k/a Euchromatin	→ Transcriptionally active
Densely packed chromatin	→ Stains dark	→ k/a Heterochromatin	→ Transcriptionally inactive

The search for genetic material

Transforming Principle

- Griffith performed experiments on Streptococcus pneumoniae

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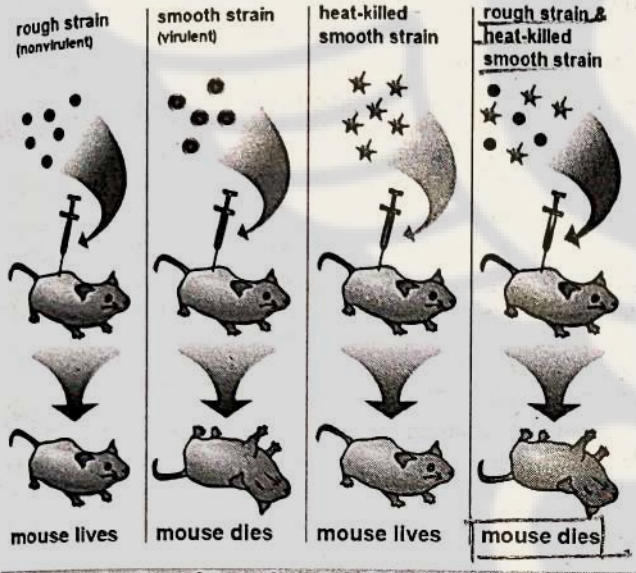
- Proved transforming principle exits but the nature of genetic material could not be defined
- It is also evident from this experiment that genetic material is **stable** as heat which killed the bacteria, at least did not destroy some of the properties of genetic material



Characterization of Transforming Principle

- Avery, MacLeod and McCarty discovered that DNA alone from S bacteria caused R bacteria to become transformed
- Used proteases, RNases and DNAase in their experiment
- They concluded that DNA is the hereditary material, but not all biologists were convinced

The Hershey-Chase experiment

- E Coli & Bacteriophage
- Radioactive ^{32} phosphorous (become part of DNA)
- Radioactive ^{35} sulphur (become part of Protein)
- Steps Infection ⟶ Blending ⟶ centrifugation
- Observation : Radioactivity ^{32} P detected in bacterial cell and no radioactivity detected in supernatant
- Unequivocally Proved DNA is the genetic material

Properties of Genetic Material

- DNA acts as genetic material
- RNA is the genetic material in Tobacco Mosaic viruses, QB bacteriophage, etc.
- DNA is a better a genetic material because
  - (i) It is able to generate its replica (Replication).
  - (ii) It is stable chemically and structurally.
  - (iii) It provides scope for slow changes (mutation): Evolution
  - (iv) It expresses itself in the form of Mendelian Characters

RNA world

- RNA is more reactive than DNA, because
  - 2'-OH group present at every nucleotide in RNA is a reactive group ⟶ makes RNA labile and easily degradable
  - Presence of **Uracil** in place of thymine ⟶ makes RNA unstable
- RNA Mutates at faster rate
  - Both DNA and RNA are able to mutate but RNA being unstable, mutate at a faster rate, this is also the reason that viruses having RNA genome mutate and evolve faster.

Preferred genetic material is DNA

- Both RNA and DNA can function as genetic material but DNA being more stable, is preferred for storage of genetic information
- Which was the first genetic material?
  - RNA was the first genetic material
  - DNA has evolved from RNA with chemical modifications that make it more stable
- RNA also acts as a messenger, adapter, structural role & catalyst

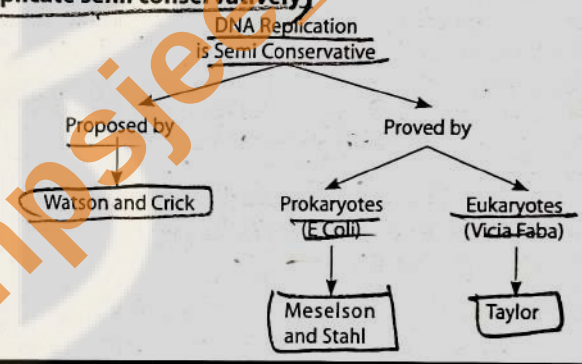
Replication: Experiments

- Watson and Crick proposed DNA replicates semi conservatively

The Experimental Proof

- Meselson and Stahl experimentally proved DNA replicates semi conservatively
- E Coli, $^{15}NH_4Cl$, 14NH4Cl CsCl
- Please note that 15N is not a radioactive isotope, and it can be separated from 14N only based on densities).
- Steps
  1. They grew E. coli in a medium containing ^{15}NH4Cl ⟶ ^{15}N was incorporated into newly synthesised DNA
  2. Then they transferred the cells into a medium with normal $^{14}NH_4Cl$ ⟶ hybrid DNA was produced
  3. DNA extracted from the culture after another generation [that is after 40 minutes, II generation] was composed of equal amounts of this hybrid DNA and of 'light' DNA

Taylor performed experiment on Vicia faba and proved DNA replicate semi conservatively



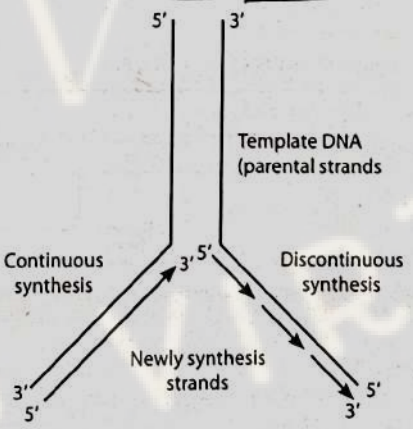
Replication: Process

Deoxyribonucleosides triphosphates has dual role

- It acts as a substrate
- It also provides energy for replication

Pach baje ulta
Ch Baje lata
Kam Kar

- DNA-dependent DNA polymerases
  - It catalyses polymerization only in 5' to 3' direction
  - DNA polymerases on their own cannot initiate the process of replication (needs primer)
- Replication fork
  - Replication occur within a small opening of the DNA helix, referred to as
- Template and Polarity
  - Template with polarity 3' to '5 - continuous replication
  - Template with polarity 5' to '3 - discontinuous replication



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- DNA ligase: joins fragments
- Origin of replication
  - replication does not initiate randomly at any place in DNA. There is a definite region in DNA where the replication originates termed as origin of replication (ori)
  - Vectors are used in biotechnology because ori is needed to produce multiple copies of a desired gene (a piece of DNA) during recombinant DNA technology. Gene of interest (a piece of DNA) does not have its own ori. Hence, it is ligated with vector DNA like plasmid of bacteria containing origin of replication for producing its multiple copies in any host organism (say E.coli)
- S phase of cell cycle

Transcription

- Transcription: DNA ⟶ RNA
- Transcription differs from DNA replication
  - In transcription, only particular segment of DNA and only one of the strands is copied into RNA
- Only DNA Strand with polarity 3'⟶5' is transcribed.
- Both the DNA strands are not copied during transcription because :
  - One segment of the DNA would code for two different proteins
  - The two RNA molecules if produced simultaneously would be complementary to each other, hence would form a double stranded RNA.
- DNA-dependent RNA polymerase
  - Use strand with polarity 3'⟶5' as template strand
  - New strand is formed in 5'⟶3' direction
- Coding Strand
  - It is a strand with polarity (5'⟶3')
  - Have sequence same as newly formed RNA
  - Does not code for anything

Transcription Unit

- Which strand to be coded is decided by transcription unit
- Transcription Unit has
  (i) A Promoter (ii) The Structural gene (iii) A Terminator region

Promoter

- Located towards 5'-end (upstream) of the structural gene
- Provides **binding site** for RNA polymerase
- It is the presence of a promoter in a transcription unit that defines the template and coding strands

Structural gene

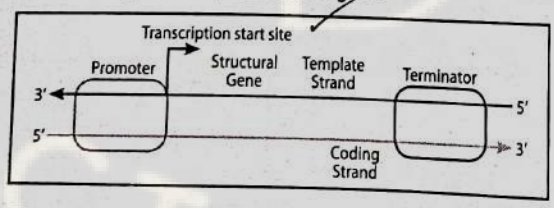
- Codes for Protein or RNA

Terminator

- Located towards 3'-end (downstream) of the coding strand
- Defines the end of the process of transcription

Regulatory sequences

- Regulatory sequences may be present further upstream or downstream to the promoter
- Function : regulates expression of a gene



The Gene

- Generally, segment of DNA that codes for tRNA, rRNA, mRNA is called as a gene
- Gene that code for mRNA—Protein is defined as Cistron

- Prokaryotes: Polycistronic mRNA: codes from several protein
- Eukaryotes: Monocistronic mRNA: codes for single protein
- Genes in eukaryotes are **split genes** having exon and introns
- Exons
  - Expressed as proteins • Appear in mature RNA
- Introns
  - Do not express them • Do not appear in mature RNA
- **Regulatory genes** do not code for any RNA or protein

Types of RNA

- mRNA provides the template for transcription
- tRNA brings amino acids (**adapter** molecule) and reads the genetic code
- rRNAs play **structural** and **catalytic** role during transcription

The process of Transcription

- Transcription is a 3 step process : initiation, elongation, termination
- DNA-dependent RNA Polymerase
  - binds to promoter, sigma (σ) factor helps in initiation
  - it is actually involved in **elongation** step of transcription
  - uses nucleoside triphosphates as substrate
  - ***also facilitates opening of the helix***
  - Termination factor (rho factor) helps termination
- Precursor of mRNA
  - The RNA polymerase II transcribes precursor of mRNA
  - This is also called as heterogeneous nuclear RNA (hn RNA)
  - hn RNA is composed of both introns and exons

Transcription

Prokaryotes	Eukaryotes
Single RNA polymerase catalyses tanscription of all types of RNA	RNA poly I rRNAs (28S, 18S, 5.8S) RNA poly II mRNA, hnRNA RNA poly III tRNA, 5 srRNA, snRNA
mRNA does not require any processing to become active	Post Transcriptional modification in nucleus Splicing : introns are removed and exons are joined (Splicing is done by snRN) Capping : methyl GTP added at 5' end Tailing : 200-300 adenylate residue added at 3' end
transcription and translation can be coupled in bacteria	The transcription and translation separate in eukaryotes

- Significance of split gene
  - Split-gene (exons interrupted by introns) arrangements represent an ancient feature of genome.
  - Presence of introns is reminiscent of antiquity,
  - Process of splicing represents the dominance of RNA

Genetic code

Genetic Code Discoveries

George Gamow	Suggested condon is made up of 3 nucleotides
Har Gobind Khorana	Synthesized RNAs (homopolymers and copolymers)
Marshall Nirenberg	Developed cell-free system for protein synthesis
Severo Ochoa	Discovered polynucleotide phosphorylase enzyme helpful in polymerising RNA in a template independent manner (enzymatic synthesis of RNA)

tg:-@chanpsice_neet

The salient features of genetic code are as follows:

(i) The codon is triplet. 61 codons code for amino acids and 3 codons UAA, UAG, UGA do not code for any amino acids, hence they function as stop codons.

(ii) Some amino acids are coded by more than one codon, hence the code is **degenerative**

(iii) The codon is **comma less**

(iv) The code is nearly **universal**

(v) AUG codes for Methionine (met) , it act as initiator codon

Mutations and Genetic Code

Point mutation

Point mutation is a change of single base pair (substitution mutation) in the structural gene for beta globin chain that results in the change of amino acid residue e.g. glutamate change to valine, results in Sickle Cell Anaemia

Six position

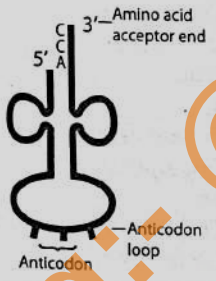
Frameshift mutation

Insertion or deletion of one or two bases changes the reading frame from the point of insertion or deletion k/a frameshift mutations

- Insertion or deletion of three or its multiple bases insert or delete in one or multiple codon hence one or multiple amino acids, and reading frame remains unaltered from that point onwards.

tRNA– the Adapter Molecule

- Secondary structure ⟶ clover-leaf
- Tertiary structure ⟶ inverted 'L' shape
- tRNA has
  - an anticodon loop: has bases complementary to the code
  - amino acid acceptor 3' end : binds to amino acid
- There are no tRNAs for stop codons
- tRNAs are specific for each amino acid
- Initiator tRNA : play a critical role in recognizing the start codon in the mRNA

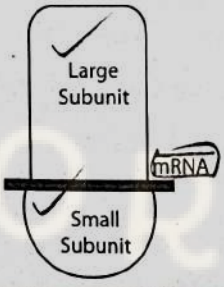


Translation

Translation refers to the process of polymerisation of amino acids to form a polypeptide

- Ribosome
  - Made up of
    - structural RNAs and about 80 different proteins
  - Subunits
    - Small subunit: mRNA attach here
    - Large subunit: joining of amino acids take place

Translation takes place in 3 steps:
1. Initiation,
2. Elongation,
3. Termination



1) Initiation

- For initiation, the ribosome binds to the mRNA
- Amino acids are activated in the presence of ATP and linked to their cognate tRNA – a process commonly called as charging of tRNA or aminoacylation of tRNA
- Charged tRNA provides energy for the formation of a peptide bond.
- The ribosome also acts as a **catalyst** (23S rRNA) in bacteria is the enzyme- **ribozyme** for the formation of peptide bond
- Protein synthesis starts at start codon (AUG)
- All enzymes are protein except ribozyme which is an enzyme but it is not protein in nature, it is a RNA.

2) Elongation

- The ribosome moves from codon to codon along the mRNA. Amino acids are added one by one, translated into Polypeptide sequences

3) Termination

- At the end, a **release factor** binds to the stop codon, terminating translation and releasing the complete polypeptide from ribosome.

Untranslated regions (UTR)

- Present at both 5'-end (before start codon) and at 3'-end (after stop codon).
- UTR sequences are not translated
- Required for efficient translation process

Regulation of gene expression

- Since, transcription and translation are energetically very expensive processes, these have to be tightly regulated.
- In **eukaryotes**, the regulation could be exerted at

(i) transcriptional level (formation of primary transcript),
(ii) processing level (regulation of splicing),
(iii) transport of mRNA from nucleus to the cytoplasm,
(iv) translational level

In Prokaryotes, the regulation is primarily exerted at Transcriptional level

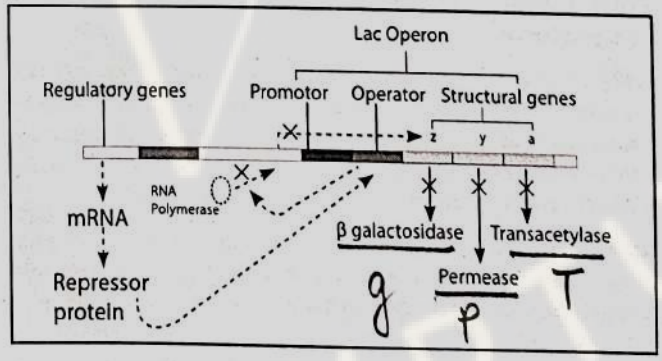
The Lac operon

- Elucidated by Jacob and Monod
- Lac Operon consist of
  - One regulatory gene
  - 3 Structural Genes

GPT

z gene - beta-galactosidase ⟶ carry hydrolysis of disaccharide
y gene – Permease ⟶ transport lactose into the cells
a gene – Transacetylase ⟶ involved transfer of an acetyl group

- Promoter, a terminator, regulator, an operator.



- The repressor of the operon is synthesized (all-the-time – constitutively) from the i gene. The repressor protein binds to the operator region of the operon and prevents RNA polymerase from transcribing the operon
- The Lactose operon expresses **as long as the Lactose is**

To:- @champsee_neet

present. When all lactose is converted into glucose and galactose, the reaction stops.

- Regulation of lac operon by repressor is referred to as negative regulation. Lac operon is under control of positive regulation as well
- Lactose act as inducer

Human genome project

- The term genome is used for **Haploid** set of chromosomes
- The Human Genome Project was a 13-year project
- The project was completed in 2003
- HGP was closely associated with **Bioinformatics** which uses computer technology to analyses biological data

Goal

Main goal of HGP was to determine sequence of base pairs

Some of the important goals of HGP were as follows:

(i) Identify all the approximately 25,000 genes in human DNA

(ii) Determine the sequences of the 3 billion chemical base pairs that make up human DNA;

(iii) Store this information in databases;

(iv) Improve tools for data analysis;

(v) Transfer related technologies to other sectors

(vi) Address the ethical, legal, and social issues (ELSI) that may arise from the project.

Methodologies

Expressed Sequence Tags

In these methods all the genes (DNA) that are **expressed** as RNA are identified

Sequence Annotation

This is a **blind approach** where all the coding and non-coding sequence are identified.

Process

- Fragmented DNA introduced into vector – amplification – sequencing of DNA done based on **Sanger's method***
- Vectors used: BAC (bacterial artificial chromosomes)
  YAC (yeast artificial chromosomes).

*Sanger is also credited for developing method for determination of amino acid sequences in proteins.

Salient Features of Human Genome

- The human genome contains 3164.7 million bp
- Average gene consists of 3000 bases
- 99.9 % nucleotide bases are exactly the same in all people
- Repetitive sequence do not code for protein. They shed light on evolution.
- Less than 2 per cent of the genome codes for proteins
- The sequence of chromosome 1 was completed in the last
- HGP identified: single base differences, SNPs – single nucleotide polymorphism

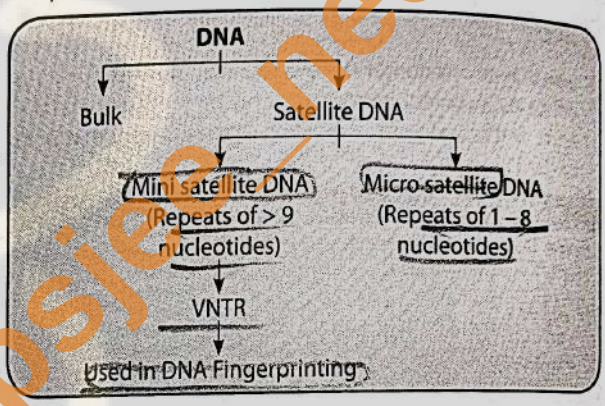
SNPs – single nucleotide polymorphism 'snips'

- If more than 1% of a population does not carry the same nucleotide at a specific position in the DNA sequence, then this variation can be classified as a SNP.
- Used in study of chromosome associated disorders

Note : Many non-human model organisms, such as bacteria, yeast, Caenorhabditis elegans (a free living non-pathogenic nematode), Drosophila (the fruit fly), plants (rice and Arabidopsis), etc., have also been sequenced.

DNA fingerprinting

- 99.9 per cent of base sequence among humans is the same, DNA fingerprinting involves identifying differences in some specific regions in DNA sequence called as **repetitive DNA**
- These repetitive DNA are separated from bulk genomic DNA as different peaks during density gradient centrifugation and are referred to as **satellite DNA**
  - Bulk genomic DNA ⟶ forms major peaks
  - Satellite DNA ⟶ forms small peaks
- Polymorphism
  - Repetitive DNA Shows high degree of polymorphism in population and also the same degree of polymorphism in an individual
  - Polymorphism arises due to mutation
  - Polymorphism plays role in evolution and speciation
  - By convention, a polymorphism is a difference in DNA sequence that occurs in ≥1% of the population i.e., have frequency greater than 0.01
- Depending on number of repetitive units, the satellite DNA is classified into many categories, such as micro-satellites, mini-satellites etc.
- In minisatellite DNA, small DNA sequence is arranged tandemly in many **copy numbers** called as Variable Number of Tandem Repeats (VNTR)



Variable Number of Tandem Repeats (VNTR)

- VNTR belongs to a class of satellite DNA referred to as mini-satellite.
- Do not code for any proteins
- Shows high degree of polymorphism
- Forensic application
- Paternity testing
- Can be used to determine genetic diversity
- Limitations of DNA fingerprinting:
  - Monozygotic twins

Technique of DNA Fingerprinting was developed by Alec Jeffreys. He used VNTR for DNA Fingerprinting

- Process

(i) Isolation of DNA,

(ii) Digestion of DNA by restriction endonucleases,

(iii) Separation of DNA fragments by electrophoresis,

(iv) transferring (Southern blotting) of separated DNA fragments to synthetic membranes, such as nitrocellulose or nylon,

(v) Hybridisation using labelled VNTR probe, and

(vi) Detection of hybridised DNA fragments by autoradiography

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29. Evolution

Theories Of Evolution

Origin of Universe

- Explained by Big Bang theory
- Singular huge explosion unimaginable in physical terms – Hydrogen and Helium formed -- gases condensed under gravitation – galaxies formed – earth formed

Origin of Earth

- Initial earth was in molten form
- Molten earth released Water vapour, methane, carbon dioxide and ammonia (no oxygen)
- UV rays from the sun broke up water into Hydrogen and Oxygen

$$H_2O \xrightarrow{\text{UV Rays}} H_2 + O_2$$

- Oxygen combined with ammonia and methane to form water, CO_2

$$O_2 + NH_4 \longrightarrow H_2O + N_2$$
$$O_2 + CH_4 \longrightarrow H_2O + CO_2$$

- Ozone layer formed ⟶ blocked UV rays ⟶ earth atmosphere cooled down ⟶ water vapor fall as a rain on earth

Origin of Life

Theory of Panspermia

- Units of life called spores were transferred to different planets including earth

Theory of spontaneous generation (abiogenesis)

- Life came out of decaying and rotting non-living matter like straw, mud, etc
- This theory is rejected by Louis Pasteur
- Louis Pasteur demonstrated that life comes only from pre-existing life (Biogenesis)
- He showed that in pre-sterilised flasks, life did not come from killed yeast while in another flask open to air, new living organisms arose from 'killed yeast'.

Theory of chemical evolution

- The idea of chemical evolution of life was developed by Oparin and Haldane
- Oparin and Haldane proposed that : the first form of life could have come from pre-existing non-living organic molecules (e.g., RNA, protein, etc.) which arose gradually from inorganic molecules

Inorganic molecule (CH_4, NH_3) ⟶ organic molecule (Amino acid, carbohydrates) ⟶ Non cellular form of Life ⟶ cellular form of life

- Theory of chemical evolution is supported by
  1) Analysis of meteorite
  2) miller's experiment

1) Analysis of meteorite

Analysis of meteorite content also revealed organic molecule such as sugars, nitrogen bases, pigment and fats indicating that similar processes are occurring elsewhere in space.

2) Miller experiment

- Inorganic molecule (CH_4, NH_3) Converted to organic molecule
- Gases used: CH_4, H_2, NH_3 and water vapour (Oxygen)
- Temperature used: 800°C
- **Observation: Amino acids, Sugar, lipids** formed (Glutamic acid, DNA not formed in this experiment)

Features of first non-cellular forms

- Giant molecule having RNA, Protein etc
- Ability to reproduce
- Formed in water

Law of Biogenesis

This law states that the first form of life arose slowly through *evolutionary forces* from non-living molecules

This is accepted by majority

Theory of Special creation

1. All living organisms (species or types) that we see today were created as such (by God)
2. Diversity was always the same since creation and will be the same in future also
3. Earth is about 4000 years old

This theory was rejected by Charles Darwin based on observation during a sea voyage in H.M.S. Beagle, Darwin stated

- Existing life forms shares similarities among themselves and also shares similarities with the life forms (ancestor) that existed million years ago
- There is a Gradual evolution of life

Some data :

Universe originated about 20 Billion years ago.
Earth formed about 4.5 billion years back.
Life appeared 500 million years after the formation of earth
First non-cellular forms of life originated 3 billion years back.
First cellular forms of life appeared on earth about2000 million years ago (mya)

Darwin's Observations

- Any population has built in variation in characteristics.
- Some useful variations enable some to survive better in natural conditions (climate, food, physical factors, etc.)
- Those having favourable variation outbreed (overproduce) k/a reproductive fitness

Reproductively fit population is selected by nature (Mechanism of evolution : **natural selection**)

⟶ Evolution

Note :

Natural selection works on population (not on individuals)

Alfred Wallace

- Worked in Malay Archipelago
- Similar conclusion as Darwin, "All the existing life forms share similarities and share common ancestors"

Note :

The geological history of earth closely correlates with the biological history of earth because, each era in geographical history shows us evidence of human and other species evolution.

- Palaeozoic era ⟶ fish, reptiles and other plants originated.
- Mesozoic era ⟶ higher reptiles like dinosaurs was seen
- Cenozoic era ⟶ Origin of humans

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Evidences for evolution

1) Paleontological evidence:

It is a study of fossils for evolution purpose
A study of fossils in different sedimentary layers indicates new forms of life have arisen at different times in the history of earth

2) Embryological support for evolution

- Given by Ernst Heckle
- He said certain features of embryonic stage (e.g., gills slit) are common to all vertebrates that are absent in adult
- Ontogeny recapitulates phylogeny
- Rejected by Karl Ernst von Baer said "Embryos never pass through the adult stages of other animals"

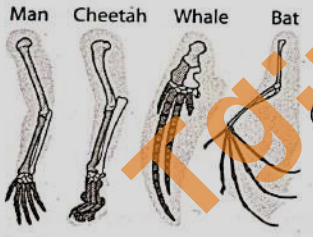
3) Homologous Organs

Common ancestor
↓
Bones of forelimbs of whales, bats, cheetah and human (all mammals)
↓
Similar anatomical structure
↓
Different functions
↓
Suggest Divergent evolution

Examples
- Vertebrate hearts or brains
- Thorn and tendrils of Bougainvillea and Cucurbita

4) Analogous Organs

Different anatomical structure
↓
Similar habitat resulted in Similar adaptive feature
↓
Perform Similar function
↓
Convergent evolution



Homologous is HArD
Homologous - Anatomy - Divergent
→ Adaptive radiation
→ Ancestor is common

Analogous is FunC
Analogous - function same - convergent

Examples
- Wings of butterfly and of birds
- Eye of the octopus and of mammals
- The flippers of Penguins and Dolphins
- Sweet potato (root modification) and potato (stem modification)

5) Biochemical similarities

Biochemical similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry

6) Natural selection

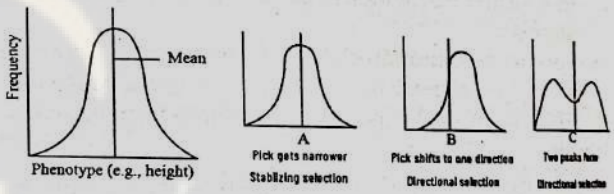
Before industrialisation
more white-winged moths on trees than dark-winged or melanised moth
↓
Post industrialisation
↓
Tree trunks became dark due to industrial smoke and lichen disappeared d/t pollution
↓
Dark-winged or melanised moth survived (gets naturally selected) as they camouflaged in dark tree trunk

Industrial melanism is an example of directional natural selection

- Effect of natural selection on population :

Natural selection is a process in which heritable variations enabling better survival are enabled, natural selection leads to:

Stabilisation	More individuals acquire mean character value
Directional	Change (more individuals acquire value other than the mean character value) e.g., Industrial melanism
Disruption	More individuals acquire peripheral character value at both ends of the distribution curve



Natural selection work on Phenotype not on genotype
Natural section works on population (non on individual)

- Other examples of natural selection:

Resistance to antibiotics, herbicides, pesticides etc These are examples of evolution by **anthropogenic action.**
Evolution is not a directed process in the sense of determinism. It is a stochastic process based on chance events in nature and chance mutation in the organisms.

Note:
Lichens can be used as industrial pollution indicators, they do not grow in areas that are polluted

7) Adaptive radiation

Original Seed eating bird located in one area of Galapagos Islands migrated to other habitat of island leading to evolution of different species k/a adaptive radiations

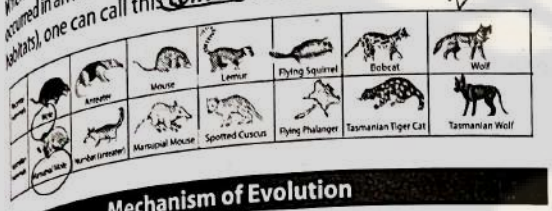
Tg:- @chanpsjee_neet

Variety of beaks of finches that Darwin found in Galapagos Island

Examples of Adaptive radiations:
- Darwin's finches,
- Placental Mammals in Australia
- Australian marsupials

Convergent evolution

When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats), one can call this **convergent evolution**.



Mechanism of Evolution

1) Darwin's theory of natural Selection

- Observations by Darwin

Natural resources are limited
↓
Population remain stable in size
↓
Variations are present in population
↓
Variations are inheritable
↓
Population having favourable variation outbreeds based on phenotype (Reproductive fitness)
↓
Gets naturally selected
↓
Population evolves

Thomas Malthus

- Two key concepts of Darwinian Theory
  - Branching descent and
  - Natural selection

Thomas Malthus inspired Darwin
- Thomas Malthus worked on Principle of Population.
- Thomas Malthus' work helped inspire Darwin to refine natural selection by stating a reason for meaningful competition between members of the same species (intraspecific competition)

☞ Darwin ignored or was unaware of mendelian "factor"

2) Theory of inheritance of acquired character

- Given by Lamarck
- Evolution occurs by use and disuse of organs
- Giraffes who in an attempt to forage leaves on tall trees had to adapt by elongation of their necks
- Acquired characters are inheritable
- Theory is rejected by everybody
- Mutation causes **speciation** (evolution) and not the minor variations (heritable) that Darwin talked about

Note:
Darwin's variations are small[1] and directional[2]. Evolution for Darwin was gradual[3] while for De Vries mutations are large[1] discontinuous[2], evolution for Devries was sudden[3] single step.

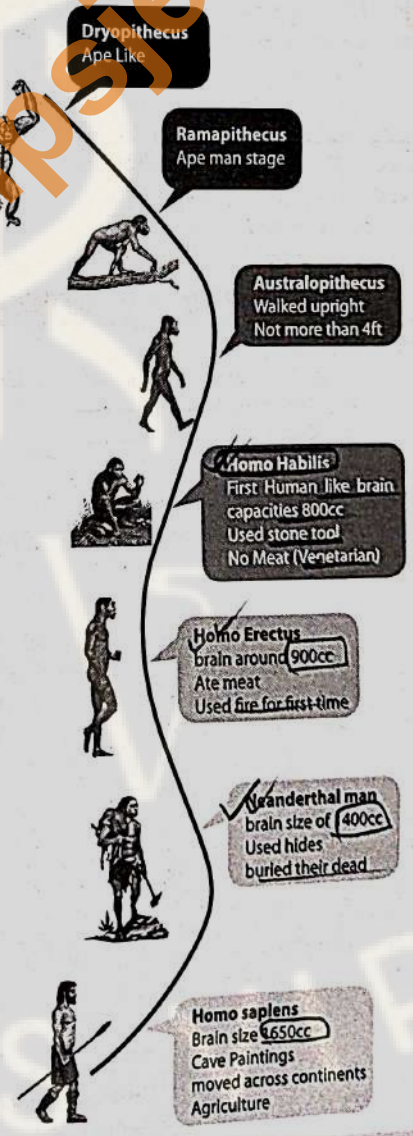
Hardy-Weinberg principle

- This principle states "frequency of occurrence of alleles of a gene remain constant through generations" i.e., the gene pool remains a constant or remains in genetic equilibrium
- The frequency of AA individuals is p^2. Similarly of aa is q^2, of Aa is 2pq. hence $p + q = 1$, hence, $p^2+2pq+q^2=1$
- ***Change of frequency of alleles result in evolution.***
- Factors that affect Hardy-Weinberg equilibrium, leads to evolution:
  1. Gene migration or gene flow,
  2. Genetic drift,
  3. Mutation,
  4. Genetic recombination
  5. Natural selection.
- The Hardy-Weinberg Law states in a large random-mating population in absence of above factors genotype frequencies are constant from generation to generation
- Change in allele frequency from generation to generation that occur by chance is k/a Genetic drift. The founder effect is a type of genetic drift where variation results when a small subset of a large population is used to establish a new colony.

A brief account of Evolution

- Lobefin fish evolved into the first amphibians
- The amphibians evolved into reptiles.
- When reptiles came down mammals took over earth.
- First mammals were like shrews. Their fossils are small sized.

Origin and evolution of man



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30. Human Health & Diseases

	Typhoid	Pneumonia	Common cold	Amoebiasis	Ascariasis	Elephantiasis or filariasis
Caused by	Salmonella typhi	Streptococcus pneumoniae and Haemophilus influenza	Rhino viruses	Entamoeba histolytica (Protozoan)	Helminth Round worm - Ascaris	Helminth Wuchereria (W. bancrofti and W. malayi)
Route	Contaminated food and water	droplets/aerosols released by an infected person	Droplets from cough or sneezes of infected person	Houseflies – infected faeces, Contaminated food water	contaminated water, vegetables	bite by the female mosquito vectors
Site	Small intestine (ileum)	Alveoli of lungs – gets filled with fluid	nose and respiratory passage (lungs)	Large intestine (amoebic dysentery)	Intestine	lymphatic vessels of the lower limbs
Symptoms	high fever, weakness, stomach pain, constipation,	fever, chills, cough and headache	Nasal congestion, sore throat, hoarseness, cough, headache,	Constipation, abdominal pain and cramps, stools with mucous and blood	Internal bleeding, muscular pain, fever, anaemia and	Swollen genital organ, lower limbs
Complication	Intestinal perforation	lips and finger nails may turn grey to bluish			blockage of the intestinal passage	
Investigation	Widal test					

Introduction

- Discovery of blood circulation ⟶ by William Harvey
- Definition of Health: Health does not simply mean 'absence of disease' or 'physical fitness'. It could be defined as a state of complete physical, mental and social well-being
- Diseases can be broadly grouped into
  - Infectious disease : transmitted from one person to another e.g. HIV
  - Non-infectious disease : Not transmitted from one person to another e.g. cancer

Common diseases in humans

Ringworm

- Caused by fungi belonging to the genera Microsporum, Trichophyton and Epidermophyton
- Site : groin or between the toes
- dry, scaly lesions on various parts of the body such as skin, nails and scalp, itching
- acquired from soil or by using towels, clothes of infected individual

Note:

Diseases transmitted through food and water:	typhoid, Amoebiasis, Ascariasis, dysentery, jaundice, cholera
Air-borne diseases:	pneumonia and common cold
Bacterial diseases:	Typhoid, Pneumonia, Dysentery, plague, diphtheria etc.

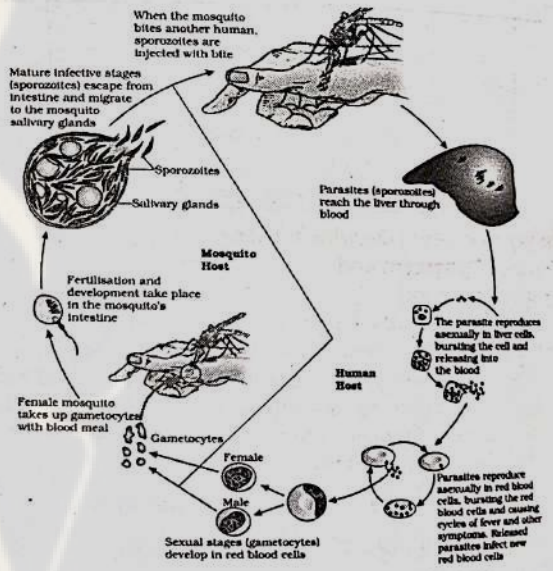
Diseases transmitted through insect vectors:	
Anopheles mosquito	malaria
Aedes mosquito	dengue and chikungunya
Culex Mosquito	filariasis

Diseases under control because of vaccination :	Polio, diphtheria, pneumonia and tetanus (DPT)
Disease completely eradicated with the use of vaccine :	Smallpox

- Gambusia fish in ponds feed on mosquito larvae and thus used to control mosquito borne diseases.

Malaria

- Caused by: Protozoan, plasmodium
- Types of Plasmodia: P. vivax, P. malaria and P. falciparum
- Malignant / fatal malaria caused by: Plasmodium falciparum
- Malarial parasite requires two hosts – human and mosquitoes – to complete its life cycle



Stages in Human

Infectious form:	Plasmodium sporozoites
Vector:	female Anopheles mosquito
Target site:	RBC
Cause of Chills and recurrent high fever:	rupture of RBC – releasing hemozoin
Asexual reproduction :	take place in human liver
Formation of male and female gametocyte :	takes place in RBC

Tg:- @chanpsiee_neet

Stages in Mosquito

- Infective stage for mosquito: gametocytes
- Fertilization (sexual reproduction) → Mosquito gut and development takes place in :
- Sporozoites are stored in: Salivary gland of mosquito

In malaria, Female Anopheles mosquito act as host and vector (transmitting agent) too.

Immunity

Ability of the host to fight the disease-causing organisms, conferred by the immune system is called immunity.

Innate Immunity

- non-specific, present at the time of birth
- This is accomplished by providing different types of barriers to the entry of the foreign agents into our body
- **Physical barriers :** Skin, Mucus coating of the epithelium lining the respiratory, gastrointestinal and urogenital tracts
- **Physiological barriers:** Acid in the stomach, saliva in the mouth, tears from eyes.
- **Cellular barriers :** Polymorpho-nuclear leukocytes (PMNL neutrophils), Monocytes, natural killer cell (a type of lymphocyte), macrophages destroy microbes by phagocytosis
- **Cytokine barriers:** Virus-infected cells secrete proteins called interferon which protect non-infected cells from further viral infection.

Acquired Immunity

- Pathogen specific, characterised by memory

Primary response of acquired immunity

- When body encounters a pathogen for the first time it produces a response called primary response
- This is a low intensity response

Secondary / anamnestic response of acquired immunity

- This is intensified response because of memory of first encounter

Cells involved in acquired immunity

T Lymphocyte and B Lymphocyte

B Lymphocytes

- B-lymphocytes produce antibodies to fight with pathogen
- Because these antibodies are found in the blood, the response is also called as humoral immune response.

T lymphocytes

- T-cells themselves do not secrete antibodies but help B cells produce them
- This is called as cell-mediated immune response or cell-mediated immunity (CMI)
- Cell-mediated immune response is responsible for the graft rejection in organ transplanted patient

Antibodies

- Antibodies are globular proteins
- Secreted by B lymphocytes
- Antibodies are found in blood (humoral immune response)
- Each antibody molecule has four peptide chains, two small called light chains and two longer called heavy chains (H2L2)
- Antigen binding site is present on both Two light chains and two heavy chains
- Two chains are held by sulphide bridge
- Types : IgA, IgM, IgE, IgG

Graft rejection

- When some human organs like heart, liver, kidney fail to function satisfactorily, transplantation is the only remedy
- But organs cannot be taken from just anybody because body is able to differentiate 'self' and 'nonself'
- Tissue matching, blood group matching are essential before undertaking any graft/transplant
- **Cell-mediated immune** response is responsible for the graft rejection.
- Patient has to take immuno-suppressants (e.g., cyclosporin) all his/her life.

Innate Immunity

Acquired Immunity

- **Active Immunity**: When a host exposed to antigens, antibodies are produced in the host body. **This response is slow and take time to effective response**
  - **Natural**: Antibodies develops in response to natural infection
  - **Artificial**: Antibodies developes in response to deliberate injection of antigen on immunization (vaccination)
- **Passive Immunity**: Readymade antibodies are given to protect the body against foreign agents. **This gives rapid response**
  - **Natural**: Antibodies (IgA) transferred from mother colostrum to baby
  - **Artificial**: Antibodies acquired directly through injection as given in case of 1) Snake bite 2) Injection Tetanus antitoxin

Vaccination and Immunisation

Vaccination

In vaccination, inactivated/weakened pathogen (vaccine) are introduced into the body ⟶ this generates memory B cell and T cell ⟶ Quick response is generated on subsequent exposure. But this is a slow response.

Passive immunization

In cases when quick response is needed as in tetanus or snake bite, ready-made antibodies are injected, this type of immunisation is called passive immunisation.

Note : hepatitis B vaccine is produced from yeast.

Allergies

Definition	exaggerated response of the immune system to certain antigens (dust, pollens, animal dander etc.) present in the environment is called allergy
Symptoms	sneezing, watery eyes, nose and difficulty in breathing
Antibody responsible	IgE (Allergeee)
Chemical involved	mast cells
Treatment	anti-histamine, adrenalin and steroids
Investigation	Allergic test : patient is exposed to or injected with very small doses of possible allergens and the reactions studied

Tg:- @chanpsee_neet

Auto Immunity

- In this body attacks self cells
- Autoimmunity means presence of antibodies or T cells that react with self-protein --- autoimmunity is a defect of acquired immunity
- Reason : autoimmunity develops due to genetic factor, there are factors also
- e.g. Rheumatoid arthritis, Myasthenia gravis etc

Immune System in the Body

Types of Lymphoid organs:
Primary lymphoid organs and secondary lymphoid organ

Primary lymphoid organs

- These are the organs where lymphocyte originate and/or mature
- Primary lymphoid organs are bone marrow and thymus
- **Bone marrow**
  - Lymphocytes are produced in bone marrow
- **Thymus gland**
  - Maturation of T lymphocytes occurs in thymus

Secondary lymphoid organs

- These are the organs where lymphocytes interact with the antigen and mature
- Secondary lymphoid organs are spleen, lymph nodes, tonsils, Peyer's patches of small intestine and appendix.
- **Spleen**
  - filter the blood by trapping blood-borne micro-organisms
  - Act as a large reservoir of erythrocytes.
- **Lymph nodes**
  - trap the micro-organisms ⟶ activates lymphocytes present there and cause the immune response.
- **Mucosa associated lymphoid tissue (MALT)**
  - It is located within the lining of the major tracts (respiratory, digestive and urogenital tracts)
  - It constitutes ~50 per cent of lymphoid tissue in human body.

AIDS

- AIDS stands for Acquired Immuno Deficiency Syndrome
- 'Syndrome' means a group of symptoms.
- Caused by : Human Immune deficiency Virus (HIV)
- HIV Virus
  - belong to retrovirus group, RNA Virus, Enveloped Virus
  - Have enzyme reverse transcriptase (RNA ⟶ DNA)
- Transmission of HIV-infection generally occurs by ***body fluids***
  - Sexual contact, transfusion of contaminated blood, multiple sexual partners, intravenous drug addicts, Children born to an HIV infected mother
- HIV/AIDS is not spread by mere touch or physical contact
- The time-lag between the infection and appearance of AIDS symptoms is usually 5-10 years
- Replication of virus inside host
  - HIV virus targets: Macrophages and Helper T cells
  - HIV virus enters macrophages and helper T cell ⟶ replicates to form viral DNA with the help of the enzyme reverse transcriptase. ⟶ this viral DNA gets incorporated into host cell's DNA and directs the infected cells to produce virus particles ⟶ Infected cell can survive while viruses are being replicated and released (AIDS has no cure)

AIDS	
Cells affected	Macrophage and Helper T cells
Opportunistic infection	E.g. Mycobacteria, Toxoplasma
Symptoms	Fever, Diarrhoea, weight loss
Test	Enzyme Linked Immuno-sorbant Assay (ELISA) For early diagnosis: Polymerase Chain Reaction (PCR)
Treatment	Anti-retroviral drugs
Death	Treatment can only prolong the life of the patient but cannot prevent death, which is inevitable
Govt Programs	National AIDS Control Organization (NACO)

Note : Helper T cell count is an indicator of immune function in patients living with HIV and one of the key determinants in treatment of HIV

Cancer

- Normal cells show a property called **contact inhibition** by virtue of which contact with other cells inhibits their uncontrolled growth.
- Cancer cells appear to have lost contact inhibition. As a result of this, cancerous cells just continue to divide giving rise to masses of cells called **tumors**.

Causes of cancer

Agents that cause cancer are called carcinogens

Physical Carcinogen	Ionising radiations like X-ray and Gamma rays Non-ionizing radiations like UV rays Damages DNA ⟶ CANCER
Chemical carcinogens	Tobacco smoke : Lung cancer
Oncogenic viruses	Certain viruses possess **Viral oncogenes** which can activate (c-onc) or proto oncogene in normal cell ⟶ causes cancer

Note: UV B rays also causes snow blindness and skin cancer

Diagnosis of cancer

Early detection essential to successfully treat the disease

Histopathological study	
Biopsy	a piece of the suspected tissue is studied under microscope
Radiological study	
CT Scan (Computed Tomography)	CT Scan uses X-rays to generate a three-dimensional image of internals of an object (e.g., bone)
MRI (magnetic resonance imaging)	MRI uses strong magnetic fields and non-ionising radiations To detect changes in tissue
X ray	Done to study internal objects (e.g. Bone)
Molecular Biology	
Antibody detection	Antibodies against cancer -specific antigens are used for detection of certain cancers. Test positive individuals are advised to avoid exposure to particular carcinogens

Treatment of cancer

Radiotherapy	Tumor cells are irradiated lethally.
Chemotherapeutic drugs	Chemotherapeutic drugs kill cancerous cells. Side effects :hair loss, anaemia, etc
Immunotherapy	α-interferon activates immune system ⟶ attack tumour cells

Best approach is to use combination of surgery, radiotherapy and chemotherapy

Tg:- @chanpsee_neet

Drugs and alcohol abuse

	Opioid (afim)	Cannabinoid	Cocaine
Derived from products	Derived from Morphine, Heroin	C Sativa Bhang, Charas, Marujuana Ganja	E Cocca Mechanism of action Dopamine serotonin
Targets	GIT, CNS	Brain, Cardiovascular System	CNS
Effect	Analgesic, Euphoria, Depressant	Abused by sportspersons	Stimulant Hallucination

Majority of these drugs are obtained from flowering parts of plants.

Co coin At. Bell Dahura

- **Morphine**
  - sedative and painkiller ⟶ useful in patients undergone surgery
- **Heroin (smack)**
  - Heroin is chemically diacetylmorphine
  - It is a white, odourless, bitter powder
  - taken by snorting and injection
  - heroin is a depressant

Heroin says oops...
Heroin : opium

- **Cocaine (Coke /crack)**
  - It interferes with neuro-transmitter **dopamine**
  - usually snorted
  - act on CNS ⟶ stimulant ⟶ euphoria and increased energy, hallucination

U drink coke, u get hallucination :
Cocaine causes hallucination

Note :
- Hallucinogenic property: Atropa belladonna, Datura, coccain
- Other drugs that are abused are: barbiturates, amphetamines, benzodiazepines etc

Tobacco

- It is smoked, chewed and snuff
- Nicotine in tobacco ⟶ act on adrenal gland ⟶ release adrenalin and nor adrenalin ⟶ raises blood pressure
- Causes cancers of lung, urinary bladder and throat
- Smoking increases carbon monoxide (CO) content in blood and reduces the concentration of homebound oxygen.
- Tobacco also causes bronchitis, emphysema, coronary heart disease, gastric ulcer, oxygen deficiency in body etc.
- Tobacco chewing ⟶ cancer of the oral cavity.

Adolescence and Drug/Alcohol Abuse

- Adolescence period: It is a period between **12-18 years**
- **Drug abuse:** When drugs are taken in amounts/frequency that impairs one's physical, physiological or psychological functions
- **Addiction:** Psychological attachment to certain effects -such as euphoria and a temporary feeling of well-being
- **Dependence:** It is the tendency of the body to manifest nausea, vomiting, anxiety etc (**withdrawal syndrome**) if regular dose of drugs/alcohol is abruptly discontinued.

Note:
- Intravenous drug abuser prone for infections like AIDS and Hepatitis B.
- Chronic use of Alcohol ⟶ **Liver cirrhosis**
- Use of drugs and alcohol during pregnancy is also known to adversely affect the foetus
- Drugs abuse by sport person: **narcotic analgesics, anabolic steroids, diuretics**

The side-effects of the use of anabolic steroids

- **In females**
  - masculinisation (features like males), aggressiveness, abnormal menstrual cycles, excessive hair growth on the face and deepening of voice.
- **In males**
  - Acne, depression, reduction of size of the testicles, breast enlargement, premature baldness, stunted growth

Tg. : @chanpsjee_neet
DOCTOR'S VIRTUE

31. Strategies for Enhancement in Food Production

Animal Husbandry

- Animal husbandry is the agricultural practice of breeding and raising livestock e.g., buffaloes, cows, pigs, horses, cattle etc
- 70 per cent of the world livestock population is in India and China but contribution to the world farm produce is only 25%

Management of Farms and Farm Animals

Dairy Farm Management

- Dairying is the management of animals for milk and its products for human consumption.
- Important step : **Selection** of good breeds
- To Improve quantity (Yield) Of milk
  - House well, provide adequate water, food, Veterinary doctor
- To Improve quality of milk
  - Stringent cleanliness, Proper storage and transport facility

Poultry Farm Management

- Includes chicken and ducks, turkey, geese etc.
- 'Bird flu virus' once affected egg and chicken

Animal Breeding

- Breed: A group of animals related by descent and similar in most characters like general appearance, features, size, configuration, etc., are said to belong to a breed.
- Animal breeding aims at increasing the yield of animals

Inbreeding

- Inbreeding refers to the mating of more closely related individuals within the same breed for **4- 6 generations**.
- Effects of inbreeding
  - increases homozygosity
  - necessary to evolve pure lines in any animals
  - helps in accumulation of superior genes and elimination of less desirable genes
  - exposes harmful recessive genes: **inbreeding depression**
  - Inbreeding depression leads to reduction in fertility and productivity
  - **Selection** of superior males and females is crucial to avoid inbreeding depression
  - To eliminate inbreeding depression: selected animal is mated with unrelated superior animal of same breed. A single outcross often helps to overcome inbreeding depression

Outbreeding

Outcrossing	Crossbreeding	Interspecific Hybridization
Breeding of animals within the same breed, but having no common ancestors on either side of their pedigree up to 4-6 generations	Superior males of one breed are mated with superior females of another breed.	male and female animals of two different related species are mated.
Best for animals that are below average in productivity in milk production, growth rate in beef cattle etc	Hisardale (Sheep) developed in Punjab by crossing Bikaneri ewes & Marino rams	A mule is the offspring of a male donkey (jack) and a female horse (mare)

✓ A single outcross often helps to overcome inbreeding depression

✓ Improved breed of cattle ⟶ Jersey , Chicken ⟶ Leghorn

Controlled breeding experiments

Artificial insemination

The semen is collected from the male that is chosen as a parent and injected into the reproductive tract of the selected female

- Problem : Success of rate of artificial insemination is low
- Solution : use MOET

Multiple Ovulation Embryo Transfer Technology (MOET)

- To improve chances of successful production of hybrids MOET is used ⟶ programme for Herd improvement
- Give FSH like hormones to cow ⟶ Produce 6 – 8 egg ⟶ Artificial insemination ⟶ Egg fertilized ⟶ 8 – 32 cell embryos recovered (non-surgically) ⟶ Transfer to surrogate mother ⟶ The genetic mother is available for another round of super ovulation

Bee-keeping

- Bee-keeping or apiculture is the maintenance of hives of honeybees for the production of honey.
- Most common species that is reared ⟶ **Apis indica.**
- Bees provide Honey, Bee wax,
- Bees are **pollinators** of many crops such as sunflower, Brassica, apple and pear

Fisheries

- Fishery is an industry devoted to the catching, processing or selling of fish, shellfish or other aquatic animal molluscs (shell-fish) and crustaceans (prawns, crabs, etc)
- Freshwater fishes : Catla, Rohu and common carp etc
- Marine fishes : Hilsa, Sardines, Mackerel and Pomfrets etc
- Difference between Aquaculture and pisciculture
  - Aquaculture involves the rearing and culture of all aquatic organisms such as fish, prawns, oysters, etc., whereas pisciculture refers to only the rearing and culture of fish
- Significant growth of global aquaculture production is called as Blue Revolution

Plant breeding

Plant breeding is the purposeful manipulation of plant species in order to create desired plant types that are better suited for cultivation, give better yields and are disease resistant

The main steps of plant breeding

1) Collection of variability:

- Genetic variability is the root of any breeding programme.
- You may select wild relative of crop
- The entire collection (of plants/seeds) having all the diverse alleles for all genes in a given crop is called **germplasm collection**

2) Evaluation and selection of parents

- Evaluate germplasm and identify parents with desired character

3) Cross hybridisation among the selected parents

- Very time-consuming and **tedious process** since the pollen
- grains from the desirable plant have to be placed on the stigma of selected female parent

4) Selection and testing of superior recombinants

- Plants that are superior to both of the parents are selected
- The **selection process is crucial** to the success of breeding programme

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• Self-pollination is done to achieve a state of uniformity (homozygosity), so that characters will not segregate in progeny.

5) **Testing, release and commercialisation of new cultivars**

• New cultivar is tested in farmers' fields, for at **least three growing seasons.**

Green revolution

• Plant breeding techniques (in 1960s) ⟶ development of several high yielding varieties of **wheat and rice** ⟶ increases in food production in country ⟶ Green revolution

• **Norman Borlaug** is often called "the father of the Green Revolution"

• **M.S. Swaminathan**, is the main architect or the Father of the Green Revolution in India through introduction of **Mexican varieties of wheat** in India. He also developed short-duration high-yielding varieties of rice including scented Basmati.

Crops developed through Plant breeding

Wheat

Development of	Semi dwarf variety of Wheat
Developed by	Nobel laureate Norman E. Borlaug
Developed at	International Centre for Wheat and Maize Improvement in Mexico
Other varieties of wheat in India	Sonalika and Kalyan Sona

Rice

Development of	Semi dwarf variety of rice developed from IR8 and Taichung Native-1
Developed at	IR 8 (International Rice Research Institute (IRRI), Philippines) Taichung Native-1 (Taiwan).
Other varieties of rice in India	Jaya and Ratna

Sugarcane

Saccharum barberi	Saccharum officinarum
Poor sugar content but grow well in north India	Thick stem, High sugar content variety of south India but not grow well in North India
Crossed these two varieties to get sugarcane that can grow in north India	

Millets

Hybrid maize, jowar and bajra have been developed in India.

Plant Breeding for Disease Resistance

Diseases caused by fungi	brown rust of wheat, red rot of sugarcane and late blight of potato
Diseases caused by bacteria	black rot of crucifers
Diseases caused by Virus	tobacco mosaic, turnip mosaic, etc.

Plant breeding for disease resistance

1) Diseases resistant varieties developed through Conventional method of breeding (hybridisation and selection)

Crop	Variety	Resistance to disease
Wheat	Himgiri	Leaf and stripe rust, hill bunt
Brassica	Pusa swarnim (Karan rai)	White rust
Cauliflower	Pusa Shubhra, Pusa Snowball K-1	Black rot and Curl blight black rot
Cowpea	Pusa Komal	Bacterial blight
Chilli	Pusa Sadabahar	Chilly mosaic virus, Tobacco mosaic virus and Leaf curl

2) Diseases resistant varieties developed by mutational breeding

• Mutations are induced by gamma radiations

• In mung bean, resistance to yellow mosaic virus and powdery mildew were induced by mutations.

3) Diseases resistant varieties developed by wild cross

• Bhindi (Parbhani Kranti) is resistant to yellow mosaic virus.

• Developed by crossing Abelmoschus esculentus (bhindi) with its wild variety

Plant Breeding for Developing Resistance to Insect Pests

Various plants show certain characteristics for insect resistance

Hairy leaves

- Cotton — Resistant to Jassids
- Wheat — Resistant to Cereal leaf beetle

Solid stem

- Wheat — Steam sawfly

Smooth leaves and loss of nectar

- Cotton — Bollworm not attracted

Crop breed by hybridization and selection for insect pest resistsance

Crop	Variety	Insect Pest
Brassica (rapeseed mustard)	Pusa Gaurav	Aphids
Flat bean	Pusa Sem 2, Pusa Sem 3	Jassids, aphids and fruit borer
Okra (Bhindi)	Pusa Sawani Pusa A-4	Shoot and Fruiit borer

Single cell protein (scp)

One of the alternate sources of proteins for animal and human nutrition is Single Cell Protein (SCP).

Single cell Protein	Advantages
Blue-green algae like Spirulina	grown easily on materials like waste water, also reduces water pollution.
Methylophilus, Methylotrophus	Have High biomass ⟶ High Protein
Mushroom	This is fungi that is used as food

Tg:- @chanpsjee_neet

Biofortification

- World facing challenge of hidden hunger
- **Hidden hunger** is a form of undernutrition that occurs when intake of vitamins and minerals are low to sustain good health
- Solution to hidden hunger is Biofortification

Definition	breeding crops with higher levels of vitamins and minerals, or higher protein and healthier fats is called Biofortification
Developed by	Indian Agricultural Research Institute, New Delhi

Examples of Fortified crops:

Maize	Lysine and tryptophan
Wheat	High protein content
Rice	Higher iron content
Vit A	Carrots, spinach, pumpkin
Vit C	Bitter gourd, bathua, mustard, tomato
Calcium	Spinach and bathua
Protein	Beans - broad, lablab, french and garden peas

Tissue culture

- Tissue culture is a **in-vitro** technique of regenerating whole plant from **explant** i.e., any part of plant in a test tube, under sterile conditions in special nutrient media.
- Nutrient medium must provide carbon sources as sucrose and inorganic salts, vitamins, amino acids and auxins, cytokinin etc
- Capacity to generate a whole plant from any cell/explant is called **totipotency**.
- Tissue culture is for crop improvement, it is possible to produce thousands of plants in short duration, this process is k/a **Micropropagation**
- All the plants that are produced are genetically same called as **somaclones**.
- Plants produced on commercial scale: Tomato Banana, Apple
- Virus free plant can be obtained by culture of **meristematic tissue** (apical and axillary)
- **Protoplasts** are isolated cells which do not have cell walls
- Isolated protoplasts from two different varieties of plants – can be fused to get hybrid protoplasts, these hybrids are called **somatic hybrids** while the process is called somatic **hybridisation**
- For Example : Potato + Tomoato = Pomato (not used commercially because of undesirable characters)

Tg:- @chanpsjee_neet

32. Microbes In Human Welfare

Microbes

- Microbes are diverse–protozoa, bacteria, fungi and microscopic plant viruses, viroids and also prions.
- Microbes like bacteria and many fungi can be grown on nutritive media to form colonies, that can be seen with the naked eyes

Microbes in household products

Curd

- Lactic acid bacteria (LAB) such as lactobacillus grow in milk and convert it to curd
- LAB produce acids that coagulate and digest the milk proteins
- LAB increases vitamin B12
- LAB also checks growth of disease causing microbes in GIT

Idli, Dosa

- Dough, used for making dosa and idli is fermented by bacteria
- The puffed-up appearance of dough is due to the production of CO_2 gas (anaerobic respiration)
- Two metabolic pathways takes place here
  - Alcoholic pathway: Pyruvate ⟶ alcohol and CO_2 (by yeast)
  - Lactic acid fermentation : Pyruvate is converted to lactic acid

Bread

- Dough, which is used for making bread, is fermented using baker's yeast (Saccharomyces cerevisiae)

Cheese

- Swiss Cheese, hv large holes (d/t CO_2) ⟶ Propionibacterium sharmanii
- Roquefort cheese ⟶ ripened by fungi

Toddy

- Toddy, is a drink, can be obtained by fermenting sap from palm
- Other fermented product: fermented fish, soyabean, bamboo shoots

Microbes in industrial products

- Microbes are used in industry to produce alcohol and antibiotics
- Production on an industrial scale, requires growing microbes in very large vessels called fermenters

Fermented Beverages

Microbes used	Saccharomyces cerevisiae (brewer's yeast)
Substrate used	Malted cereals and fruit juices
Metabolic reaction	Alcoholic fermentation
Product	Ethyl alcohol
Beverage without distillation	Wine and beer
Distilled beverage	Whisky, brandy and rum

Antibiotics

- Antibiotics are chemical substances, which are produced by some microbes and can kill other (disease-causing) microbes
- First antibiotic discovered is Penicilin, Discovered by : Fleming
- **Penicillin** is produced by fungus Penicillium notatum ⟶ kills Staphylococci bacteria
- Penicillin full potential established by Ernest Chain and Florey
- Fleming, Chain and Florey were awarded the Nobel Prize in 1945, for this discovery.
- Antibiotics are useful in bacterial diseases such as plague, whooping cough (kali khansi), diphtheria (gal ghotu) and leprosy (kusht rog)

Note : Relationship between antibiotic producing fungus and bacteria is **Amensalism**

Chemicals, Enzymes and other Bioactive Molecules

Fungal Products

Aspergillus Niger	Citric acid
Trichoderma polysporum	Immunosuppressive agent in organ-transplant patients
Saccharomyces cerevisiae	Ethyl alcohol
Monascus purpures	Produce statin ⟶ lowers blood cholesterol

Bacterial Products

Acetobacter aceti	Acetic acid
Clostridium butylicum	Butyric acid
Lactobacillus	Lactic acid
Streptococcus	Streptokinase useful in myocardial infarction

Other microbial products

- Lipase : Used in detergents ⟶ remove oily stains
- Pectinases and proteases ⟶ Clear bottled juice

Microbes in sewage treatment

Municipal waste-water is also called sewage ⟶ major component is human excreta ⟶ have large organic matter and microbes

Sewage treatment plants (STPs)

Primary treatment

- In this Large and small physical particle are removed
  - Floating debris is removed by ⟶ sequential filtration
  - Grit (soil and small pebbles) are removed by ⟶ sedimentation
- Solid that settles down is called Primary sludge
- Supernatant that floats out is called effluent

Secondary treatment or biological treatment

Aeration tank

- Effluent is passed into large aeration tanks ⟶ air is pumped ⟶ growth of aerobic microbes k/a flocs forms (mass of fungus+ bacteria) ⟶ these microbes digest organic matter

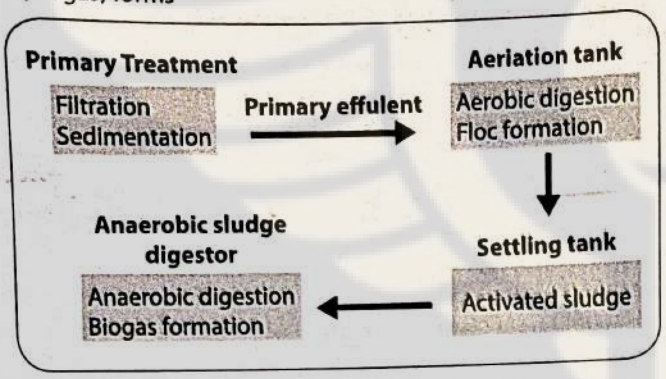
Sedimentation tank

- Effluent is passed into sedimentation tank ⟶ flocs settled down k/a activated sludge

Tg:- @chandjee_neet

Anaerobic sludge digestor

- Here anaerobic bacteria digest ⟶ bacteria and fungi in the flocs ⟶ **methane, hydrogen sulphide and carbon dioxide** (Biogas) forms



The Ministry of Environment and Forests has initiated **Ganga Action Plan** and **Yamuna Action Plan** ⟶ proposed to build a large number of sewage treatment plants

BOD (biochemical oxygen demand)

- BOD refers to amount of the oxygen that would be consumed if all organic matter in one liter of water were oxidized by bacteria
- BOD is a measure of the organic matter present in the water
- Greater the BOD of waste water, more is its polluting potential.
- The sewage water is treated till the BOD is reduced

Microbes in production of biogas

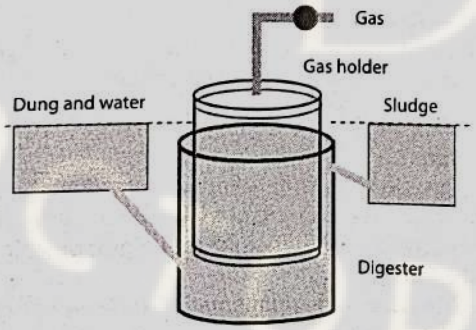
Methanogens (e.g., Methanobacterium)

- Methane producing bacteria
- Found in :
  - Found in the anaerobic sludge during sewage treatment.
  - Also present in the rumen (a part of stomach) of cattle
- Metabolic pathway: Anaerobic digestion
- Substrate used: cellulosic material
- Gas produced: **Methane, CO_2, H_2**
- Nutritional activity :These bacteria help in the breakdown of cellulose present in rumen of cattle

Note : Humans cannot digest cellulose

Biogas plant

- Excreta (dung /gobar) of cattle, rich in methanogens, can be used for generation of biogas (gobar gas)
- Biogas plant consists of a concrete tank, floating cover
- Spent slurry can be used as fertilizer
- Developed by Indian Agricultural Research Institute (IARI) and Khadi and Village Industries Commission (KVIC).



Microbes as biocontrol agents

- Bio control refers to the use of biological methods for controlling plant diseases and pests.
- Advantages of Bio control methods over insecticides
  - insecticides and pesticides chemicals are toxic to human beings, animals and pollute our environment
  - chemical methods kill both useful and harmful life forms indiscriminately
  - Bio control methods do not eradicate pest completely, rather keep it at manageable levels ⟶ maintains biodiversity, food chain

Bio Control Agent	Targets
Ladybird	Aphids
Dragonflies	mosquitoes
Trichoderma (fungus)	Kills root born pathogen
Baculoviruses (Nucleopolyhedrovirus)	• attack insects • species-specific, narrow spectrum • no negative impacts on plants, mammals, birds, fish or even on non-target insects • excellent bio control agent • useful in integrated pest management programme
Bacillus thuringiensis	butterfly caterpillars

Bacillus thuringiensis

- Control butterfly caterpillars
- Bacillus thuringiensis ⟶ available in sachets as dried spores which are mixed with water and sprayed onto vulnerable plants such as brassicas and fruit trees ⟶ these are eaten by the insect larvae ⟶ toxin is released, caterpillar larvae get killed

Microbes as biofertilisers

- **Organic farming** emphasised the use of biofertilisers to avoid problems associated with overuse of chemical fertilisers
- Biofertilisers are organisms that enrich the nutrient quality of soil by adding nitrogen , phosphorous etc to soil
- Source of biofertilisers : bacteria, fungi and cyanobacteria

Nitrogen fixing bacteria

- Rhizobium forms association with roots of leguminous plant and fix nitrogen
- Azospirillum and Azotobacter can fix atmospheric nitrogen while free-living in the soil

Fungus

- Genus Glomus form association with roots of plants called mycorrhiza
- Fungus provide phosphorous to plant
- Plant provide nutrition to fungus

Nitrogen fixing Cyanobacteria

- Cyanobacteria are autotrophic microbes many of which can fix atmospheric nitrogen, e.g. Anabaena, Nostoc, Oscillatoria
- Cyanobacteria (e.g., Azolla) fix Nitrogen in leaves of fern and paddy field
- Cyanobacteria shows association with coralloid root of cycas
- Blue green algae also add organic matter to the soil

Tu:-@chanrejee_neet

33. Biotechnology Principle and Processes

What is Biotechnology?

Biotechnology deals with techniques of using live organisms or enzymes from organisms to produce products and processes useful to humans

Biotechnology involve **genetically modified** organism

Example of Biotechnology processes : Test tube baby, developing vaccine, correcting defective gene

Making curd, bread or wine, though microbial product but these are not part of biotechnology process

Principles of biotechnology

Techniques of biotechnology:

- **Genetic engineering** (Recombinant DNA technology)
  - Alter the Genetic material (DNA and RNA) ⟶ microbe is modified ⟶ changes the phenotype of organism
- **Bioprocess engineering**
  - Growing modified microbes in ambience ⟶ vaccine, enzyme etc is produced

Traditional hybridisation procedures used in plant and animal breeding, very often lead to inclusion of undesirable genes this limitation is overcome by biotechnology which allows only set of desirable genes into the target organism

Construction of First recombinant DNA

Stanley Cohen and Herbert Boyer **isolated** antibiotic resistance gene from *Salmonella Typhi* by molecular scissors – restriction enzymes ⟶ The cut piece of DNA was then linked with the plasmid **(Vector)** DNA by DNA Ligase ⟶ recombinant DNA is **introduced** into E coli which multiplied using DNA polymerase enzyme ⟶ multiple copies of antibiotic resistance gene formed in **E Coli** (cloning)

Isolation of the Genetic Material (DNA)

Component	Digestive enzyme
Bacteria	Lysozyme
Plant cells	Cellulase
Fungus	Chitinase
RNA	Ribonuclease
Proteins	Protease

- DNA is precipitate with chilled ethanol
- DNA that separates out can be removed by **spooling**

Cutting of DNA at Specific Locations

- DNA is cut at specific location by restriction endonuclease

Discovery of restriction endonuclease

- In 1963, Two enzymes were discovered from E Coli which protect E Coli from bacterial infection (bacteriophage)
  - Methylase : It adds methyl group to palindrome of E Coli
  - Restriction **endonuclease** : Cut palindrome of virus
- First restriction endonuclease that was characterized – HIND II

Convention for naming restriction enzyme

EcoRI comes from Escherichia coli RY 13

1. First letter indicates genus E for E Coli
2. Second two letters come from the species of prokaryotic cell from which enzyme is isolated (co of E coli)
3. R is strain of E Coli RY 13
4. Roman numbers following the names indicate the order in which the enzyme was isolated from strain of bacteria

Action of Restriction nuclease

- Types
  - Exonucleases remove nucleotides from the ends of DNA
  - Endonucleases make cuts at specific positions within DNA
- Restriction endonuclease
  - Restriction endonuclease recognises a specific palindromic nucleotide sequence in the DNA ⟶ cut the strand of DNA a little away from the centre of the palindrome sites ⟶ sticky ends are formed that can be joined by DNA ligase
  - EcoRI recognition sequence is 5' GAATTC 3'
  - When cut by the same restriction enzyme, the resultant DNA fragments have the same kind of 'sticky-ends' and these can be joined together (end-to-end) using DNA ligases

Separation and isolation of DNA fragments

Agarose Gel electrophoresis

Motive	Fragments cut by restriction endonuclease are separated by **Gel electrophoresis**
Charge	DNA fragments are negatively charge, move towards anode
Separation	Fragments are separated based on **size**, smaller moves farther
Gel	Gel is obtained from sea weed (red algae)
Elution	The separated bands of DNA are cut out from the agarose gel and extracted from the gel piece
Visualize DNA	Use **ethidium bromide** followed by UV exposure --- orange colour
Sieving effect	Provided by gel

Cloning vector

- Cloning vectors produces multiple copies of desired gene
- Copy number is the number of molecules of an individual plasmid that is typically found in a single bacterial cell
- More the copy number, more the copies of target DNA can be cloned
- Vectors:
  - Plasmid
  - Bacteriophage : have high copy number
  - Vectors used in Human Genome Project : BAC (bacterial artificial chromosomes), and YAC (yeast artificial Chromosomes)

Features of cloning vector

1) Origin of replication (ori)

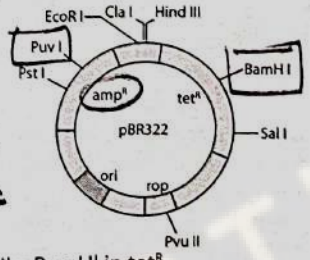
- This is a sequence from where replication starts
- ori responsible for controlling the copy number of DNA
- Foreign DNA linked to ori also replicates when vector DNA replicates. This can also be called as in vivo cloning or making multiple identical copies of any template DNA

2) Cloning sites

- Vector preferably should have single recognition site for the commonly used restriction enzymes
- Presence of more than one recognition sites within the vector will generate several fragments

3) pBR 322

- Bollivar and Rodrigues synthesized pBR 322
- pBR322 is the plasmid and most used cloning vector of E. coli.
- Ampicillin (amp^R) & tetracycline (tet^R) are selectable markers.



- It has ori and different cloning like BamHI in tet^R
- PvuI and PstI in amp^R
- rop codes for the proteins involved in the replication of plasmid.

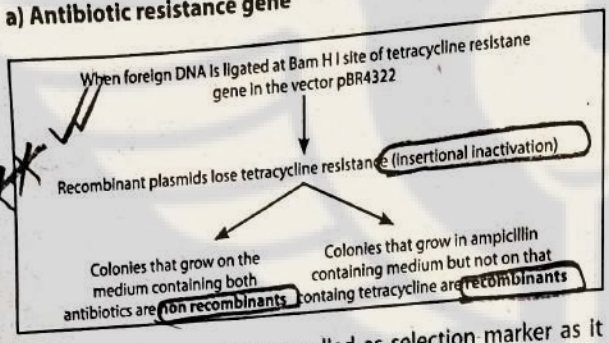
4) Selectable marker

- Selectable marker, helps in identifying transformants and non transformants

T.G:- @chapsies_neet

- Antibiotic resistance genes are considered useful selectable markers for E. coli
- Antibiotic resistance gene allow the growth of only transformants in the media

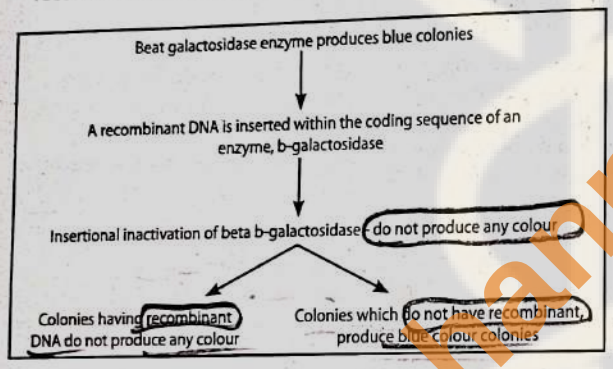
a) Antibiotic resistance gene



Antibiotic resistance gene are called as selection marker as it helps in selection of recombinants.

b) Beta galactosidase enzyme

- Selection of recombinants due to inactivation of antibiotics is a cumbersome procedure because it requires simultaneous plating on two plates having different antibiotics. Therefore, alternative selectable markers (e.g. Beta galactosidase) have been developed
- Beta galactosidase help differentiate recombinants from non-recombinants on the basis of their ability to produce colour



c) Ampicillin resistance gene

if a recombinant DNA bearing gene for resistance to an antibiotic (e.g., ampicillin) is transferred into E. coli cells, the host cells become transformed into ampicillin-resistant cells. When transformed cells are spread on agar plates containing ampicillin, only transformants will grow, untransformed recipient cells will die. The ampicillin resistance gene in this case is called a selectable marker.

5) Vectors for cloning genes in plants and animals

Vector	Host cell (to which vector delivers a gene)
pbr 322	Bacterium
Agrobacterium	Plant cell
Retrovirus	animal cell

Agrobacterium tumefaciens

- It is a pathogen of Dicot plants
- It transfers its T DNA into plant cell and transform normal plant cells into a tumorous cells
- Modified Ti plasmid (tumor inducing plasmid) is used as vector to deliver gene of interest in plant cell

Retrovirus

- Retroviruses have the ability to transform normal animal cells into cancerous cells
- Retrovirus is disarmed and then used to deliver desirable genes into animal cells.

Competent Host

- Host cell must be made competent to take up DNA
- DNA is a hydrophilic molecule, it cannot pass through cell membranes host (bacterial cell)
- Transformation is a procedure through which a piece of DNA is introduced in a host bacterium

1) To Pass DNA into host cell

- Treat bacterial cell with divalent cation (calcium) ⟶ this creates pores in cell wall ⟶ Heat shock treatment [ice ⟶ 42°C ⟶ ice] is given which enables bacteria to take up DNA
- Animal cell ⟶ micro-injection technique recombinant DNA is directly injected into the nucleus of an animal cell
- Plant cell ⟶ biolistic or gene gun (micro-particles of gold or tungsten is used) : plants, cells are bombarded with high velocity micro-particles of gold or tungsten coated with DNA
- Disarmed pathogen vectors like retrovirus having recombinant DNA are used to infect the cell

Obtaining the Foreign Gene Product

Heterologous expression refers to the expression of a gene in a host organism which does not naturally have this gene eg Insulin is not produce naturally by E Coli but if insulin gene is introduced into E Coli then it starts producing Insulin, so here E Coli is called **Heterologous host** which **produced recombinant protein**

Bioreactor

- For higher yields of desired proteins, the cells are multiplied in a continuous culture system in bioreactors.
- Bioreactor is a vessel where large volumes (100-1000 litres) of culture can be processed.
- A bioreactor provides the optimal conditions for desired product
- The most commonly used bioreactors are of stirring type
- Stirring type bioreactors are of two kinds:

Simple stirred tank bioreactor, Sparged stirred-tank bioreactor

Simple stirred tank bioreactor	Sparged stirred-tank bioreacto
Has stirrer which helps in uniform mixing and availability of oxygen throughout the bioreactor.	This has increased surface area for oxygen transfer than simple stirred-tank

Downstream Processing

- Downstream processing includes Separation and purification
- Add preservative, do clinical trial, do quality control testing

PCR

- PCR stands for Polymerase Chain Reaction
- Multiple copies of the gene (or DNA) of interest is synthesized in vitro procedure
- Steps of PCR :

Denaturation	Separation of DNA strands 95°C
Annealing	Joining of DNA primer 55°C Primer is small chemically synthesised oligonucleotides that are complementary to the regions of DNA
Extension / elongation / polymerization	Occurs at 72°C Taq polymerase isolated from Thermus aquaticus is used in this process

- Amplification : above steps of PCR can be repeated to make billion copies of DNA, such repeated amplification is achieved by the use of a thermostable DNA polymerase which remain active during the high temperature induced denaturation of double stranded DNA
- After 30 cycles, what began as a single molecule of DNA has been amplified into **more than a billion copies**
- Uses of PCR : Forensic study (DNA fingerprinting), Biotechnology, HIV testing, Gene Therapy

Tg:-@clampise_cet

34. Biotechnology and Its Applications

Applications of biotechnology includes

Therapeutics, diagnostics, genetically modified crops for agriculture, processed food, bioremediation, waste treatment, and energy production

Bioremediation employs the use of living organisms, like microbes, in the removal of contaminants, pollutants, and toxins from soil, water

Demand of food supply

- Green revolution ⟶ improved crop varieties ⟶ tripled food supply ⟶ but this is not enough for human population
- Increase in food production have been mainly due to the use of **better management practices and use of agrochemicals** (fertilisers and pesticides)
- Problem : Agrochemicals are expensive
- Solution : use genetically modified plants

Advantages of Genetically modified plants

- Crops became more tolerant to abiotic stresses (cold, drought,)
- Reduced reliance on chemical pesticides (pest-resistant crops).
- Helped to reduce post-harvest losses.
- Increased efficiency of mineral usage by plants
- Enhanced nutritional value of food, e.g. **golden rice, i.e. Vitamin 'A' (carotene) enriched rice**
- Traditional hybridization ⟶ often leads to inclusion of undesirable genes, this limitation is overcome by Biotechnology. Biotechnology isolate and introduce only one or a set of desirable genes without introducing undesirable genes into the target organism.

Genetically Modified Plants

Bacillus thuringiensis

- Bacillus thuringiensis bacterium produce Bt toxin
- Bt toxin gene has been cloned from the bacteria and been expressed in plants to provide resistance to insects without the need for insecticides; in effect created a bio-pesticide
- Examples : Bt cotton, Bt corn, rice, tomato, potato & soyabean

Bt Cotton

- Bacillus thuringiensis produce proteins that kill insects
- Bt toxin is insect group specific
  - Lepidopterans (tobacco budworm, armyworm),
  - Coleopterans (beetles)
  - Dipterans (flies, mosquitoes)
- Bt toxin exist as crystalline inactive form, gets activated in alkaline pH – binds to midgut epithelial cell receptor in bollworm (**not pathogenic to cattle**) create pores that cause cell swelling and lysis and eventually cause death of the insect
- Specific Bt toxin genes were isolated from Bacillus thuringiensis and incorporated into the several crop with the help of vector *Agrobacterium tumefaciens* plants such as cotton

Gene	Plants gets protection from	Plant
cry I Ac, cry II Ab	Cotton bollworm	Cotton
cry I Ab	Corn borer	Corn / Maize

Tobacco Plant

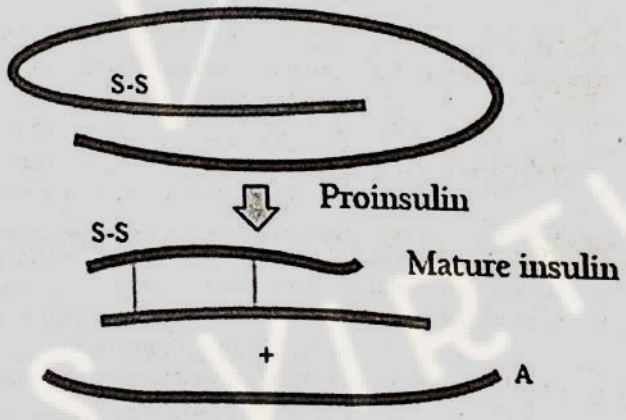
- A nematode **Meloidegyne incognitia** infects the roots of tobacco plants and causes a great reduction in yield.
- Nematode specific genes (DNA) were isolated from nematode and introduced into plant cell using **vector Agrobacterium**
- This Nematode's DNA produces both sense and anti-sense RNA in the host (Plant cell) cells.
- These two RNA's being complementary to each other formed a double stranded RNA (dsRNA)
- When nematode feeds on plant cell, Ds RNA enters into nematode, binds to and prevents (interfere) translation of the mRNA (**silencing**). This mechanism is called as RNA interference
- The consequence is that the parasite cannot survive in a transgenic host

RNA interference

- RNAi takes place in all eukaryotic organisms
- It is a a method of **cellular defence**.
- This method involves **silencing** of a specific mRNA due to a complementary **dsRNA** molecule that binds to and prevents translation of the mRNA (silencing).
- The source of this complementary RNA could be from an infection by viruses having RNA genomes or mobile genetic elements (transposons) that replicate via an RNA intermediate

Biotechnological applications in medicine

- Insulin used for diabetes was earlier extracted from pancreas of slaughtered cattle and pigs ⟶ develops allergic reaction
- Insulin consists of two short polypeptide chains: chain A and B Two chains are linked together by disulphide bridges
- Insulin is synthesised as pro hormone which contains an extra stretch called the **C peptide**. This C peptide is not present in the mature insulin and is removed during maturation into insulin.
- The main challenge for production of insulin using rDNA techniques was getting insulin assembled into a mature form. Eli Lilly an American company prepared two DNA sequences corresponding to A and B chains of human insulin and introduced them in plasmids of E. coli to produce insulin chains.
- Chains A and B were produced separately, extracted and combined by creating **disulphide bonds** to form human insulin.
- Insulin cannot be administered orally because it is protein in nature, it denatured in acidic pH



tg: @chamsiee_neet

Gene Therapy

Gene therapy is the insertion of genes into an individual's cells and tissues to treat diseases especially hereditary diseases

Adenosine deaminase (ADA) deficiency

- Adenosine deaminase (ADA) enzyme is crucial for the immune system to function
- ADA deficiency is caused due to the deletion of the gene for adenosine deaminase
- **Treatment**
  - **Temporary Cure**
    - Bone marrow transplantation
    - Enzyme replacement therapy
  - **Permanent cure (Gene Therapy)**
    - Infusion of Genetically engineered lymphocytes
      - Blood lymphocytes are cultured outside body, functional ADA cDNA* (using a retroviral vector) is then introduced into these lymphocytes
      - **Problem:** Patient requires periodic infusion of such genetically engineered lymphocytes as lymphocytes are not immortal
      - **Solution :** Infuse Genetically engineered lymphocytes at early embryonic stages

* **Complementary DNA (cDNA)** is a DNA synthesized from a single-stranded RNA template in a reaction catalysed by the enzyme reverse transcriptase.

Molecular Diagnosis

Molecular diagnostic methods help early diagnosis of disease

Probe Hybridization technique

Probe	Single stranded radioactive DNA or RNA
Hybridization	Probe hybridise (binds) to its complementary DNA
Detection	Hybridized probe is detected using autoradiography
Inference	Probe cannot bind to Mutated gene ⟶ do not appear in auto radiography Probe can bind to normal gene ⟶ appear in autoradiography

Polymerase Chain Reaction (PCR)

- PCR can detects very low concentration of pathogen even when the symptoms of the disease are not yet visible
- PCR detects low amount of DNA by amplication of DNA
- PCR is used to :
  - Detect HIV in early stages in suspected AIDS patients
  - Detect mutations in genes in suspected cancer patients
  - Identify many other genetic disorders

ELISA (Enzyme Linked Immunosorbent Assay)

- ELISA is based on the principle of antigen-antibody interaction
- It can detect antigen or antibodies Detect HIV

Transgenic animals

- Animals that have had their DNA manipulated to possess and express an extra (foreign) gene are known as transgenic animals
- Over 95 % of all existing transgenic animals are **mice**

Uses of Transgenic animals

- To study normal physiology and development
  - e.g., study of complex factors involved in growth such as insulin-like growth factor
- Study of disease:
  - To study diseases like cancer, cystic fibrosis, rheumatoid arthritis and Alzheimer's
- Transgenic animals produce biological products
  - **α-1-antitrypsin** used to treat **emphysema**
  - first transgenic cow, Rosie, produced **alpha-lactalbumin** enriched milk (2.4 grams per litre).
- Transgenic animals are also used to test vaccine safety

Ethical issues

- Genetic modification of organisms can have unpredicatable results when such organisms are introduced into the ecosystem.
- Therefore, Indian Government has set up organisations such as **GEAC** (Genetic Engineering Approval Committee), which will make decisions regarding the validity of GM research and the safety of introducing GM-organisms for public services.
- **Biopiracy** is the term used to refer to the use of bio-resources by multinational companies and other organisations without proper authorisation from the countries and people concerned without compensatory payment
- The diversity of rice (2 lac varieties) in India is one of the richest in the world.
- United states had bio pirated Indian origin turmeric neem, basmati rice for its aroma, etc

Tg: @chamsjee_neet

① Term Ecology → Ernest hackel ② Father of Ecology → Reiter. ③ Of of Indian Ecology → R. Mishra

35. Organism and Population

Ecology

Biological Organisation:

Macromolecules → cells → tissues → organs, → individual organism

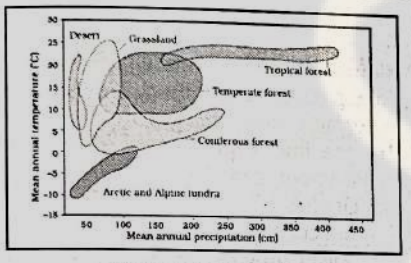
Ecological organization

Individual organism → population → communities, → ecosystems → biomes

- Ecology is a subject which studies the interactions among organisms and between the organism and its physical (ablotic) environment.
- Father of Ecology in India : Ramdeo Misra
- Physiological ecology tries to understand how different organisms are adapted to their environments in terms of not only survival but also reproduction

Biomes

Earth rotates around sun
Earth tilt at axis
↓
Variation in temperature and light on Earth
↓
Leads to formation of biomes Earth tilt at axis →



- Tropical Forest
- Desert
- Temperate forest
- Grassland

Ecological Niche

The condition an organism can tolerate (E.g., Temperature, water salinity, Light etc.) and the resources (E.g., food, Space etc.) organism use is k/a Ecological Niche of that organism

Abiotic Factors

Temperature

- Temperature affects **kinetics of enzymes** → affects physiological function of organism
- A few organisms can tolerate and thrive in a wide range of temperatures k/a **eurythermal organisms** e.g. Man
- Vast majority of animals are restricted to a narrow range of temperatures k/a **stenothermal organisms**

Water

Some organism tolerates wide range of salinity of water k/a **euryhaline** organisms and those that are restricted to a narrow range are k/a **stenohaline** organism)

Light

- Light affect photosynthesis and photoperiodism in plant
- Light also affect animal's foraging, reproductive and migratory activities
- Red algae can be found in deepest of water because it can absorb the blue light that reached the deepest part of the ocean

Soil

- Climate determines soil composition → soil determines vegetation → Vegetation determines the supported animals
- In the aquatic environment → type of benthic animals → determined by sediment-characteristics.

Response to abiotic factors

Regulators

- Organism ability to maintain constant internal environment (e.g. Temperature, Osmolality) is called k/a Homeostasis
- Homeostasis can be achieved by:
  - I) Physiological means
    E.g. profuse sweating in summer, Shivering in winter
  - II) Behavioral means
    E.g. In winter lizard bask in Sun
- All **birds and mammals**, very few lower vertebrate are capable of such regulation (Thermoregulation and osmoregulation), these are called as regulators
- Evolutionary biologists believe that the 'success' of mammals is largely due to their ability to maintain a constant body temperature

Confirmers

- Majority (99%) of animals and nearly all plants cannot maintain a constant internal environment as it is an energy consuming process.
- These animals resign themselves to surrounding, and k/a conformers
- Why very small animals are rarely found in Polar Regions?
: Small animals have large surface area to volume ratio → loose heat to surrounding → can't tolerate cold

In cold region we found big size animals because of small surface area to volume Ratio ×

- Why most conformers had not evolved to become regulators? because thermoregulation is energetically expensive for many organisms
- Confirmers either migrate or suspend in surroundings

Migrators

- The organism can move away temporarily from the stressful habitat to a more hospitable area and return when stressful period is over
- Keolado National Park (Bharatpur) in Rajasthan host thousands of migratory birds coming from Siberia

Suspend

- The organism, if unable to migrate, reduce their metabolic activity and go into a state of 'dormancy'
- Dormant stage in winter → Hibernation (e.g. Bear)
- Dormant stage in summer → Aestivation (e.g. snail, fish)
- Dormant stage in Zooplankton → Diapause

Adaptation

- Adaptation is any attribute of the organism (morphological, physiological, behavioural) that enables the organism to survive and reproduce in its habitat
- Many adaptations have evolved over a long evolutionary time and are genetically fixed.

Tg: @chanpsc_neet

Examples :

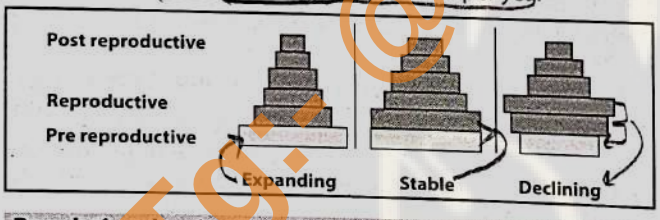
Kangaroo rat	meets its water need by fat oxidation (Physiological adaptation)
Desert plant	CAM Pathway, Sunken stomata
Opuntia (Desert Plant)	leaves reduced to spine
Mammals in cold regions	shorter ears and limbs (Allen's rule)
Polar seal	have fat blubber, act as insulator
Lizard	in winter ⟶ bask in sun (behavioural adaptation)
Deep sea animal	can tolerate high pressure (biochemical adaptation)
Archaebacteria (Thermophiles)	can tolerate hot water springs and deep-sea hydrothermal vents because of thermo-resistant enzymes (biochemical adaptation)
Antarctic fishes	developed proteins that act as antifreeze

Altitude sickness

- High altitude ⟶ low atm pressure ⟶ less oxygen ⟶ nausea, fatigue and heart palpitations (Altitude sickness) ⟶ increase in RBC, Shift of O2 disso Curve to right (Acclimatization)
- This is a physiological adaptation.

Population

- **Population** refers to the members of an inbreeding species (sexually reproducing) living in a geographical area.
- a group of individuals resulting from even asexual reproduction is also generally considered a population for the purpose of ecological studies
- *Natural selection* operates at ***population level***
- **Population ecology** links ecology to population genetics and evolution
- Population attributes (features)
  - Birth rates
  - Death rates
  - Sex ratio
  - Age distribution
- Birth rates and death rates refer to per capita births and deaths
- If in a pond there were 20 lotus plants last year and through reproduction 8 new plants are added
- Birth rate = 8/20 = 0.4 offspring per lotus per year



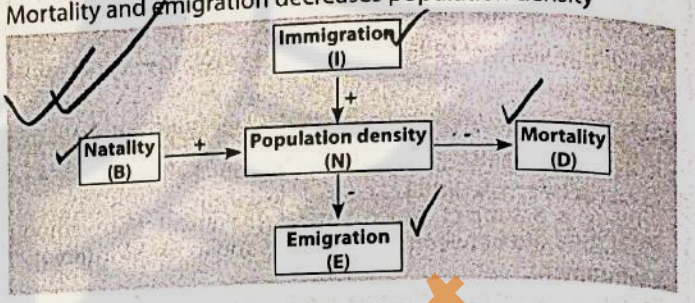
Population density (Population size)

- Total number is generally the most appropriate measure of population density
- But in some cases, e.g. in case of Banyan tree, biomass is a more meaningful measure of the population size, because of its enormous role in community
- Indirect estimation of population size
  - To measure population of fish in lake ⟶ measure fish caught per trap
  - To measure population of tiger ⟶ measure pugmarks, faecal pellets

Population Growth

Natality	⟶ number of births during a given period
Mortality	⟶ number of deaths
Immigration	⟶ number of individuals that have come into habitat
Emigration	⟶ number of individuals who left the habitat

Natality and immigration increase population density
Mortality and emigration decreases population density



Growth Models

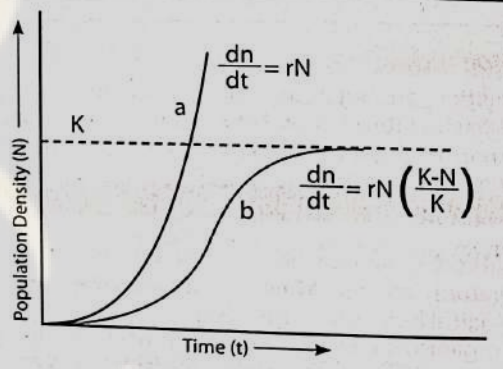
Exponential growth

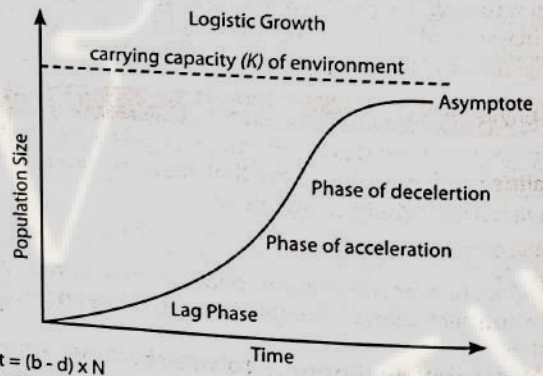
When resources in the habitat are unlimited, any species can grow exponentially

J shaped Curve

Logistic growth (Verhulst-Pearl Logistic Growth)

- No population of any species in nature has unlimited resources to permit exponential growth.
- The maximum population size of the species that the environment can sustain indefinitely is called as carrying capacity (K)
- Sigmoid curve
- The logistic growth model is considered a more realistic.
- Asymptote in a logistic growth curve is obtained, when K = N





$dN/dt = (b - d) \times N$
Let (b-d) = r, then
$dN/dt = rN$
$N_t = N_0 e^{rt}$
re

$$\frac{dn}{dt} = rN\left(\frac{K-N}{K}\right)$$

N_t = Population density after time t
N_0 = Population density at time zero
r = Intrinsic rate of natural increases
e = The base of logarithms (2.71828)

N = Population density at time t
r = Intrinsic rate of natural increases
K = Carrying capacity

Tg: @chanpe_neet

Life history variation

The 'r' is called the 'intrinsic rate of natural increase' and is a important parameter chosen for assessing impacts of any otic or abiotic factor on population growth.

eproductive fitness or Darwinian fitness is represented by ger r value

opulation evolve to maximize their reproductive fitness

rganisms breed only once in their lifetime ⟶ Pacific salmon sh, bamboo etc

Population Interactions

n nature, animals, plants and microbes do not and cannot live n isolation but interact in various ways to form a **biological ommunity.**

dation (+, -)

Predators keep population of prey under control

Biological control methods adopted in agricultural pest ontrol are based on the ability of the predator to regulate rey population

Absence of predator creates havoc

- **Prickly pear cactus** introduced into Australia caused havoc by spreading rapidly in absence of predator later cactus feeding moth was introduced into country to control cactus
- Illegal introduction of the African catfish **Clarius Bariepinus** for aquaculture ⟶ posing a threat to the indigenous catfishes of our Rivers
- **Eichhornia crassipes** ⟶ Multiplies rapidly in stagnant Water (terror of Bengal)

Predators maintain species diversity

Starfish Pisaster is an important predator, when all the starfish were removed experimentally; more than 10 species of invertebrates became extinct

Predators are "prudent"

If a predator is too efficient and overexploits its prey, then the prey might become extinct and following it, the predator will also become extinct for lack of food. This is the reason why predators in nature are 'prudent"

Adaptation to avoid Predation

ome species are cryptically-coloured (camouflaged)

- Monarch butterfly ⟶ highly distasteful to its predator
- Acacia, Cactus ⟶ plant have thorn to avoid cattle
- Calotropis ⟶ produce poisonous cardiac glycosides to avoid cattle and goat
- Various plants produce ⟶ nicotine, caffeine, quinine, strychnine, opium, etc. as defences against grazers and browsers

ote: Phytophagous insect are those insect which feed on plant p and other parts of plants

ompetition (+, +)

Darwin said interspecific competition is a potent force in rganic evolution.

It is generally believed that competition occurs when closely elated species compete for the same resources that are imiting, but this is not entirely true, because :

Competition may exist between totally unrelated species

g. Flamingoes and resident fishes are unrelated species which mpete for their common food, zooplankton

Competition may occur even when resources are NOT mited

g. Abingdon tortoise in Galapagos Islands became extinct ter goats were introduced on the island, apparently due to the eater browsing efficiency of goats.

- This is called as **Interference competition** where the feeding efficiency of one species is reduced due to the interference of the other species
- Interference competition leads to exclusion of weaker species k/a Gauze's 'Competitive Exclusion Principle'

3) Related species do not necessarily compete for resources

MacArthur showed that five closely related species of warblers living on the same tree were able to avoid competition and co-exist, this called as **MacArthur's Resource partitioning**

Competitive release

- Shown by Connell's elegant field experiments
- When competitively superior barnacle Balanus were removed, Chathamalus expanded its distributional range

Parasitism (+, -)

- Parasitic Adaptations :
  - loss of unnecessary sense organs,
  - presence of adhesive organs or suckers
  - loss of digestive system
  - **high reproductive capacity**
- Ectoparasites live outer side of host body
  - **Cuscuta** plant , has lost its chlorophyll and leaves in the course of evolution, grow on hedge plants
  - Other parasitic plants are *Orobanche* and *Striga* etc
- Endoparasite live inside the host body
  - Liver fluke (Fasciola, a trematode parasite) depends on two intermediate hosts (a snail and a fish) to complete its life cycle.
  - Malarial parasite (Plasmodium) needs Mosquito and human to spread to complete the life cycle
- Brood parasitism - Parasitic bird lays its eggs in the nest of its host and lets the host incubate them

Commensalism (+, 0)

- One species benefits and the other is neither harmed nor benefited
  - Orchid growing as an epiphyte on a mango branches
  - Cattle egret and grazing cattle
  - Sea anemone and the clown fish

Amensalism (0, -)

- One species is harmed whereas the other is unaffected
- E.g., Penicillium produces antibiotics that kills bacteria

Mutualism (+, +)

- This interaction benefits both the interacting species
  - Lichens : fungus and algae association
  - Mycorrhizae : fungi and roots of higher plants
  - Fig tree and female wasp
  - Orchid Ophry and bee : sexual deceit, pseudocopulates

Species A	Species B	Name of Interaction
+	+	Mutualism
-	-	Competition
+	-	Predation
+	-	Parasitism
+	0	Commensalism
-	0	Amensalism

Tg:-@chandscience_neet

36. Ecosystem

Ecosystem : Structure

An ecosystem is a self-sustainable functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.

Types of Ecosystems

Terrestrial ecosystem	Forest, grassland and desert etc
Acquatic ecosystem	Pond, lake, wetland, river and estuary etc
Man-made ecosystem	Crop fields and an aquarium

Worldwide sum of all ecosystems = Biosphere

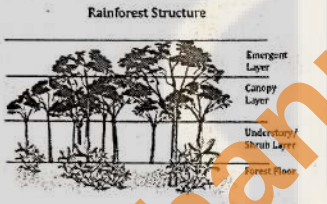
Structural feature of an ecosystem

Species composition

Autotrophs	Phytoplankton, algae, floating, submerged plants etc
Consumers	e.g., zooplankton
Decomposers	fungi, bacteria and flagellates etc

Stratification

- Vertical distribution of different species occupying different levels is called stratification.
- For example, trees occupy top vertical strata or layer of a forest, shrubs the second and herbs and grasses occupy the bottom layers.



Functional Components of Ecosystem

1) Productivity 2) Decomposition
3) Energy Flow 4) Nutrient cycling

Productivity

Primary production

- It is defined as the amount of biomass or organic matter produced per unit area by plants during photosynthesis
- It is expressed as weight (g / m2) or energy (kcal / m2)

Productivity

- The rate of biomass production is called productivity.
- It is expressed as (g / m² /year) or energy (kcal / m²/yr)

Gross primary productivity

GPP of an ecosystem is the rate of production of organic matter during photosynthesis.

Net primary productivity (NPP)

A considerable amount of GPP is utilised by plants in respiration
GPP – R = NPP

Secondary productivity

It is rate of formation of new organic matter by consumers

Maximum Productivity is seen in tropical rain forest

Because more solar energy and resources are available in tropics

Ocean have low productivity

- Despite occupying about 70 per cent of the surface, the productivity of the oceans are only 55 billion tons, because In ocean, sunlight is the main limiting factor which decreases the rate of photosynthesis. Decrease in rate of photosynthesis decreases the growth of aquatic plants and animals
- **The ocean is the most stable ecosystem**

Decomposition

- Breakdown of complex organic matter into inorganic substances like carbon dioxide, water and nutrients is called decomposition
- Raw material for decomposition: **Detritus**
- Dead plant remains such as leaves, bark, flowers and dead remain of animals, fecal matter, constitute detritus

Five steps of decomposition

1) Fragmentation

- Detritivores (e.g., earthworm) break down detritus into smaller particles k/a fragmentation

2) Leaching

- Water soluble inorganic nutrients go down into the soil horizon and get precipitated as **unavailable salts**

3) Catabolism

- Bacterial and fungal enzymes degrade detritus into simpler inorganic substances k/a catabolism

4) Humification

- Accumulation of a dark coloured amorphous substance; humus is called Humification
- Humus contain lignin, resin etc , hence highly resistant to microbial action and undergoes decomposition at an extremely slow rate
- Being colloidal in nature humus serves as a ***reservoir of nutrients***

5) Mineralization

- Release of inorganic nutrients from humus by some microbes is called Mineralisation

All the above steps in decomposition operate ***simultaneously*** on the detritus

Factors affecting decomposition:

- Decomposition is largely an oxygen-requiring process
- Detritus rich in lignin and chitin: decomposition rate ↓
- Detritus rich in sugar and nitrogen: decomposition rate ↑
- Warm and moist environment: decomposition rate ↑
- low temperature and anaerobiosis: decomposition rate ↓

Energy flow

Photosynthetically active radiation (PAR).

- It is the light available for photosynthesis (400 to 700 nm)
- Of the incident solar radiation less than 50 % is PAR
- Plants capture only 2-10 per cent of the PAR

Producers

- In Terrestrial ecosystem ⟶ herbaceous and woody plants
- In Aquatic ecosystem ⟶ phytoplankton, algae and higher plants.

Tg- @chandsee_neet

Primary Consumers

- Animals feed on the producers, the plants, they are called primary consumers
- Primary consumers are invariable herbivores.
- E.g., insects, birds and mammals in terrestrial ecosystem and molluscs in aquatic ecosystem are herbivores

Secondary consumer

- If the animals eat other animals which in turn eat the plants (or their produce) they are called secondary consumers

Primary carnivores

- The consumers that feed on herbivores are called primary carnivores
- Primary carnivores are actually secondary consumers

Grazing food chain (GFC)

Grass (Producer) → Goat (Primary Consumer) → Man (Secondary Consumer)

Detritus food chain (DFC)

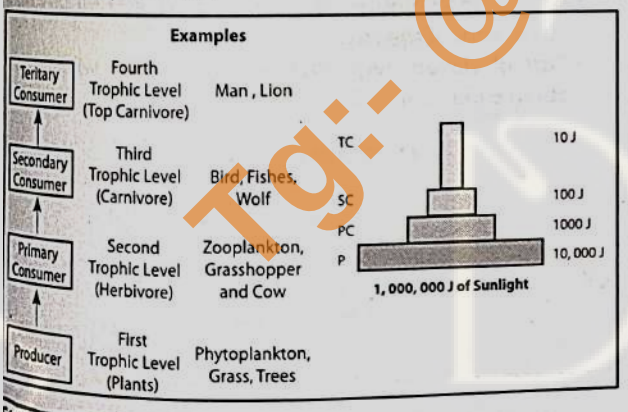
- Begins with dead organic matter
- It is made up of decomposers (fungi and bacteria)
- Decomposers are also known as saprotrophs
- Decomposers secrete digestive enzymes that breakdown dead and waste materials into simple, inorganic materials, which are subsequently absorbed by them (extracellular digestion)

Organism that eats both plants and animals are called omnivores e.g., cockroaches, crows, human beings etc.

- In Aquatic ecosystem, GFC is major conduit for energy flow.
- In terrestrial ecosystem, DFC is major conduit for energy flow.

Tropic Level

- Based on the source of their nutrition or food, organisms occupy a specific place in the food chain that is known as their trophic level
- Note the tropic levels :



Standing crop

- Biomass at a particular trophic level is k/a Standing Crop
- Measured as the mass of living organisms (biomass) or the number in a unit area.
- Biomass of a species is expressed in terms of fresh or dry weight
- Biomass in terms of dry weight is more accurate as wet (water content) weight may vary based on the physiological and environmental conditions of the species.

10 per cent law

- Only 10 per cent of the energy is transferred to each trophic level from the lower trophic level
- Maximum energy is in **first trophic level**, amount of energy decreases at successive trophic levels
- Therefore, this limits the number of trophic levels in a both grazing and detritus food chain

Laws followed by Ecosystem

1) First law of thermodynamics

- One form of energy is converted to another
- Plants convert light energy to chemical energy

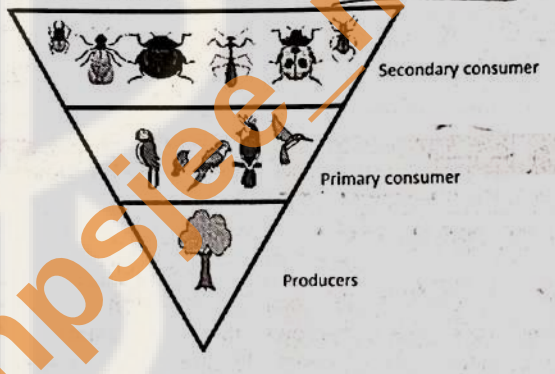
2) Second Law of thermodynamics

- In food chain, energy is lost in respiration, to counter this, continuous input of energy from sun takes place

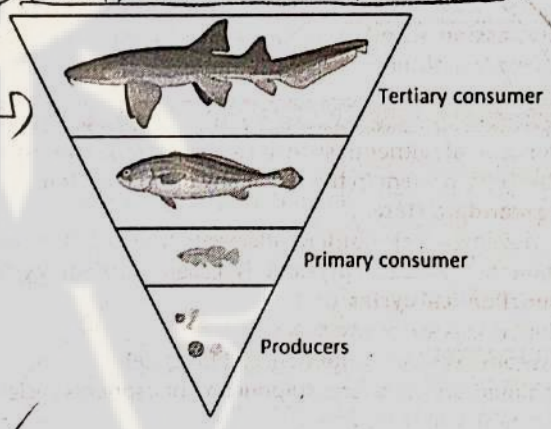
Ecological pyramids

- In most ecosystems, all the pyramids, of number, of energy and biomass are upright, except
  - Pyramid of number in forest ecosystem is inverted
  - Pyramid of biomass in aquatic ecosystem is inverted

Inverted pyramid of number in forest ecosystem



Inverted pyramid of biomass in aquatic ecosystem



Pyramid of energy in all ecosystem is always upright

Any calculations of energy content, biomass or numbers, has to include **all** organisms at that trophic level.

Limitations of ecological pyramids:

- It does not take into account the same species belonging to two or more trophic level
- It assumes a simple food chain, no place for food web
- Saprophytes are not given any place

Ecological succession

- An important characteristic of all communities is that their composition and structure constantly change in response to the changing environmental conditions

Tg:- @chanpsiee_neet

- The gradual and fairly predictable change in the species composition of a given area is called ecological succession
- These changes lead finally to a community that is in near equilibrium with the environment and that is called a **climax community**
- Very first species that invade a bare area are k/a **pioneer species**
- The entire sequence of communities that successively change in a given area are called **sere(s)**.
- The individual transitional communities are termed seral stages or **seral communities**
- Succession and evolution would have been parallel processes at that time

Primary succession	Secondary succession
Succession in areas where no living organisms ever existed, say bare rock is called primary succession	Succession in areas which lost all the living organisms that existed there e.g. due forest fire is called secondary succession
begins in newly cooled lava, bare rock, newly created pond etc.	begins in abandoned farm lands, burned or cut forests, lands that have been flooded
Slower process	faster than primary succession

Xerarch succession	Hydrarch succession
takes place in dry areas	takes place in wet area
Pioneer species - Lichen	Pioneer species - Phytoplankton
Lichen secrete acid to dissolve rock - soil formation – bryophytes - grass - forest (mesic condition)	Phytoplankton - rooted-submerged plants - free-floating plants, - reed swamp - marsh-meadow, shrub and forest (mesic condition)

All succession whether taking place in water or on land, proceeds to a similar climax community – the mesic.

Nutrient cycling

The amount of nutrients, such as carbon, nitrogen, phosphorus, calcium, etc., present in the soil at any given time, is referred to as the **standing state.**

The movement of nutrient elements through the various components of an ecosystem is called **nutrient cycling / biogeochemical cycles**

Nutrient cycles are of two types:

(a) Gaseous cycle (e.g., nitrogen, carbon cycle)

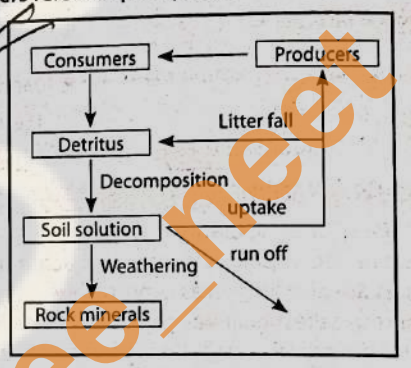
(b) Sedimentary cycle (e.g., sulphur and phosphorus cycle)

Carbon cycle

- Reservoir of carbon
  - 71 per cent carbon is found dissolved in oceans
  - Fossil fuel also represent a reservoir of carbon
- Sources for releasing CO_2
  - Burning of wood, forest fire and combustion of organic matter etc
- Reason for increased rate of release of CO_2 into atmosphere
  - deforestation and massive burning of fossil fuel

Phosphorous cycle

- Reservoir of Phosphorous - Rock
- Weathering of rock releases phosphorous ⟶ absorbed by roots of plants ⟶ Herbivores ⟶ dead organism ⟶ decomposers releases phosphate



Difference between Carbon and Phosphorous cycle

- Atmospheric inputs of phosphorus through rainfall are much smaller than carbon inputs
- Gaseous exchanges of phosphorus between organism and environment are negligible.
- Unlike carbon cycle, there is no respiratory release of phosphorus into atmosphere

Ecosystem services

- Ecosystem services include cycle nutrients, generation of fertile soils, providing wildlife habitat etc.
- **Robert Constanza** put price tags on ecosystem services
- He put an average price tag of US $ 33 trillion a year
  - Soil formation accounts for about 50 per cent of the cost
  - Recreation and nutrient cycling etc account for less than 10 per cent of the cost
  - Cost of climate regulation and habitat for wildlife cost about 6 per cent each.

TG: @cbsenseet

37. Biodiversity And Conservation

Biodiversity

- There are more than 20,000 species of ants, 3,00,000 species of beetles, 28,000 species of fishes and 20,000 species of orchids.
- Biodiversity (= Heterogenity) is the term popularised by Edward Wilson

Levels of Biodiversity

Genetic diversity

- Rauwolfia vomitoria is a medicinal plant, it shows genetic diversity in terms of potency and concentration of chemical reserpine, other examples are rice (50k strains), mango (1000 varieties) etc.

Species diversity

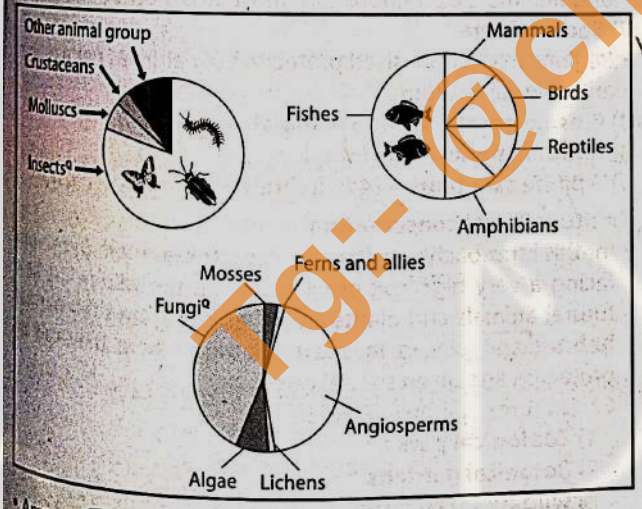
- Western Ghats have a greater amphibian species diversity than the Eastern Ghats

Ecological diversity

- India has a greater ecosystem diversity e.g. deserts, rain forests, mangroves, coral reefs etc.

How Many Species are there on Earth and How Many in India?

- Species inventories are more complete in temperate than in tropical countries
- According to the International Union for Conservation of Nature and Natural Resources (IUCN) (2004), the total number of plant and animal species described so far is slightly more than 1.5 million
- Robert May places the global species diversity at about 7 million.
- According to May's global estimates, only 22 per cent of the total species have been recorded so far
- Species inventories are more complete in temperate than in tropical countries
- More than 70 % of all the species are animals, (Animals > plants)
- Insects are the most species-rich taxonomic group, out of every 10 animals on this planet, 7 are insects



- Among invertebrates insects shows maximum diversity
  Insects > Mollusc > other animal groups
- Among vertebrates fishes show maximum diversity
  Fishes > Birds > Reptile > amphibian > mammal
- Among plants diversity is as follows
  Fungi > Angiosperm > Algae > Pteridophytes
- The group Fungi has more species than all the vertebrate species combined
- Biologist are not sure about diversity amongst prokaryotes, because
  - Conventional taxonomic methods are not suitable for identifying microbial species
  - many species are simply not culturable under laboratory conditions

India's share of the global species diversity is an impressive 8.1 per cent. That is what makes our country one of the 12 mega diversity countries of the world

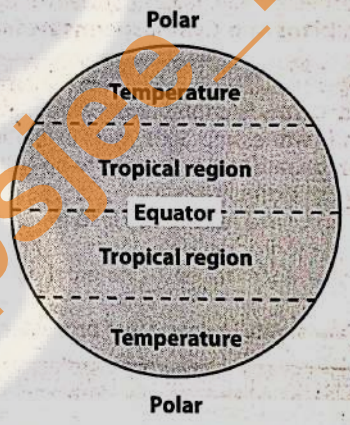
Patterns of Biodiversity

Latitudinal gradients

Species diversity decreases as we move away from the equator towards the poles, reasons:

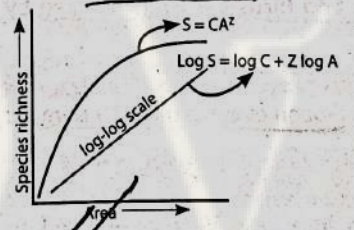
1) Tropical latitudes have remained relatively undisturbed for millions ⟶ evolution ⟶ species diversification
2) Tropical environments, unlike temperate ones, are less seasonal, more constant and predictable ⟶ niche specialization
3) There is more solar energy available in the tropics ⟶ productivity is higher

✓ Tropical Amazonian rain forest has greatest biodiversity on earth



Species-Area relationships

- Alexander von Humboldt explained Species-Area relationships
- He observed that within a region species richness increased with increasing explored area, but only up to a limit
- Relationship graph is ⟶ rectangular hyperbola
- On a logarithmic scale, the relationship is ⟶ straight line



log S = log C + Z log A
where
S = Species richness
A = Area
Z = Slope of line (regression coefficient)
C = Y-intercept

Z value

- Z lies in the range of 0.1 to 0.2
- Independent of the taxonomic group or the region
- For large continent,
  - Z value lies in the range of 0.6 to 1.2
  - Shows steeper curve
  - E.g. for frugivorous (fruit-eating) birds and mammals in the tropical forests of different continents, Z=1.15, steeper curve (matlab birds aur mammal ki jyada variety kam area me milti hai)

Tg:-@chanpsjee_neet

The importance of Species Diversity to the Ecosystem

- Communities with more species, generally, tend to be more stable than those with less species
- Features of stable community
  - do not show too much variation in productivity from year to year
  - resistant or resilient to occasional disturbances
  - resistant to invasions by alien species
- David Tilman performed long-term ecosystem experiments using outdoor plots , showed :
  - Plots with more species showed less year-to-year variation in total biomass
  - Increased diversity contributed to higher productivity
- Paul Ehrlich used rivet popper hypothesis
  The hypothesis suggests the importance of species richness in the maintenance of the ecosystem.

Airplane ⟶ ecosystem / Rivets ⟶ Species

Loss of Biodiversity

- **IUCN (International Union for conservation of nature)** red list documents **endangered** species
- IUCN lists recent extinctions include the dodo (Mauritius), Quagga (Africa), Thylacine (Australia), Steller's Sea Cow (Russia) and three subspecies (Bali, Javan, Caspian) of tiger.
- Mainly **Amphibians and Gymnosperms** are facing the threat of extinction
- Threat of extinction
  Gymnosperms >Amphibians > Mammals >Birds
- We are currently witnessing 'Sixth Mass Extinction' current
- species extinction rates are estimated to be 100 to 1,000 times faster than earlier extinctions
- Loss of biodiversity in a region may lead to
  - decline in plant production,
  - lowered resistance to environmental perturbations eg drought
  - increased variability in ecosystem processes

Causes of biodiversity losses

Four major causes (**'The Evil Quartet'**).

Habitat loss and fragmentation:

- Amazon rain forest ("lungs of the planet")
  - cleared for cultivating soya beans and for raising beef cattle
  - used to cover more than 14 per cent of the earth's land surface, now cover no more than 6 per cent
- **Mammals** (e.g., elephants) **and birds** are badly affected by fragmentation

Over-exploitation

- Steller's sea cow, passenger pigeon overexploited by humans ⟶ now extinct

Alien species invasions

- Introduction of Nile perch into Lake Victoria ⟶ led to extinction of more than 200 species of cichlid fish
- Invasive weed species carrot grass (Parthenium), Lantana and water hyacinth (Eicchornia) ⟶ threat to environmental damage
- Catfish Clarias gariepinus ⟶ threat to indigenous catfishes

Co-extinctions

- When a species becomes extinct, the plant and animal species associated with it in an obligatory way also become extinct.
- When a host fish species becomes extinct, its unique assemblage of parasites also meets the same fate.
- Another example is the case of a coevolved plant-pollinator mutualism where extinction of one invariably leads to the extinction of the other

Biodiversity conservation

Why Should We Conserve Biodiversity?

Narrowly utilitarian arguments

- Humans derive countless direct economic benefits from nature through firewood, fibre, construction material, medicine etc.
- **Bioprospecting** is exploring molecular, genetic and species-level diversity for products of economic importance

Broadly utilitarian argument

- Amazon forest produces 20 % of the total oxygen in the earth
- Ecosystem provides pollination, pleasures of walking through thick woods, watching spring flowers or a bulbul's song etc

Ethical argument

- A **moral duty** to care for well-being of other species

How do we conserve Biodiversity?

in situ (on site) conservation

- In situ conservation, the endangered species are protected in their natural habitat so that the entire ecosystem is protected.
- e.g., saving the entire forest to save the tiger

1) Hot spots

- it is unrealistic and economically not feasible to conserve biological wealth ⟶ Biodiversity "Hot Spots" regions have been identified
- Biodiversity Hot spots are regions with very **high levels of species richness and high degree of endemism** (that is species confined to that region and not found anywhere else)
- Total number of biodiversity hotspots in world: 34.
- Biodiversity Hotspots in India are **four** in number
- Hot spots covering Indian regions : Western Ghats and Sri Lanka, Indo-Burma and Himalaya
- Hot spots cover less than 2% of earth's land but can reduce the ongoing mass extinctions by almost 30 per cent.

2) Sacred grove

- Regions that emphasised protection of nature as per religious and cultural tradition.

3) Biosphere reserves (14 in India)

4) National parks (90 in India)

5) Wildlife sanctuaries (448 in India)

Ex situ (off site) conservation

- In this approach, **endangered** or **threatened** (organisms facing a very high risk of extinction in the wild in the near future) animals and plants are **taken out from their natural habitat** and placed in special setting where they can be protected and given special care.
- Ex situ conservation examples:
  1) **Zoological parks,**
  2) **Botanical gardens**
  3) **Wildlife safari parks**
  4) **Cryopreservation of gametes**
  5) **In vitro fertilization**
  6) **Seed bank**
  7) **Tissue culture propagation**

Also note :

The historic Convention on Biological Diversity ('The Earth Summit') held in Rio de Janeiro in 1992, called upon all nations to take appropriate measures for conservation of biodiversity and sustainable utilisation of its benefits.

Tg:- @chanpee_neet

38. Environmental Issues

- **Pollution** is any undesirable change in physical, chemical or biological characteristics of air, land, water or soil.
- Agents that bring about such an undesirable change are called as **pollutants**
- Environment (Protection) Act → **1986**

Air pollution and its control

- Air (Prevention and Control of Pollution) Act, 1981
- Smokestacks of thermal power plants, smelters and other industries release (1) particulate and (2) gaseous air pollutants

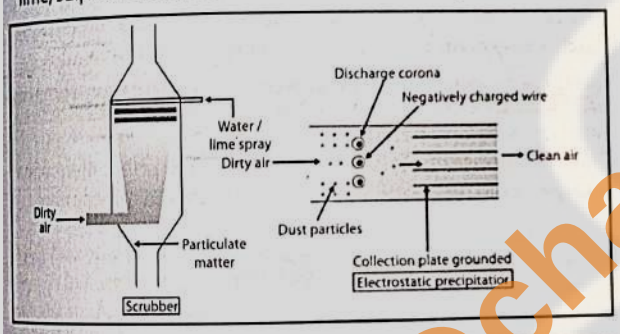
Removal of particulate matter

- **Electrostatic precipitator** removes over 99 % particulate matter
- Electrodes → produce corona of electrons → electrons attach to dust particles giving them a net negative charge → collecting plates attract the charged dust particle

According to Central Pollution Control Board (**CPCB**), particulate size 2.5 micrometres or less in diameter (PM 2.5) are responsible for causing the greatest harm to human health

Removal of gaseous air pollutant

- A scrubber can remove gases like Sulphur dioxide
- In a scrubber, the exhaust is passed through a spray of water or lime, sulphur dioxide is removed as calcium sulphate



Automobiles Pollution

- Catalytic converters, having expensive metals namely platinum-palladium and rhodium are fitted into automobiles to reduce emission of poisonous gases.
- Function of catalytic converter:
  - Unburnt hydrocarbons → carbon dioxide and water
  - Carbon monoxide → carbon dioxide
  - Nitric oxide → nitrogen gas
- Catalytic converter is inactivated by Lead in Petrol

Controlling Vehicular Air Pollution: A Case Study of Delhi

As per Supreme Court directive all the buses of Delhi were converted to run on CNG by the end of 2002

Advantages of CNG

- CNG burns most efficiently, unlike petrol or diesel,
- CNG is cheaper than petrol or diesel,
- CNG cannot be siphoned off and adulterated like petrol or diesel

Euro III norms

- Sulphur to be controlled at 350 parts-per-million (ppm) in diesel and 150 ppm in petrol → Goal: Sulphur 50 ppm
- Aromatic hydrocarbons are to be contained at 42 per cent → Goal: Hydrocarbon 35 % (42→35)

Bharat stage emission standards

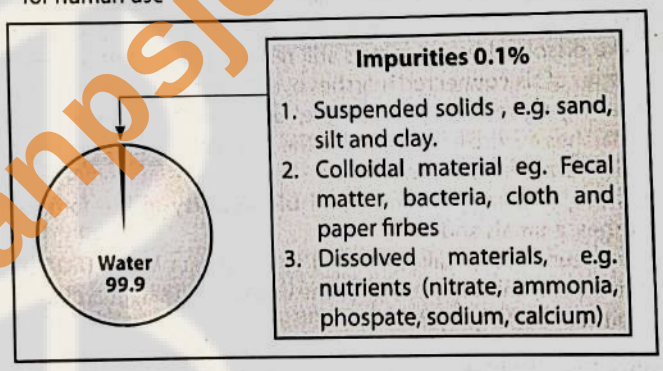
- Government of India laid down auto fuel policy which aims at **reducing Sulphur and aromatic content** in petrol & diesel fuels.
- Bharat stage emission standards is instituted in India to regulate Air pollution. It is based on European regulation (Euro Norms)
- There are a set of norms laid down by the government, which has to be followed by every automobile industry in order to control air pollution. The vehicles have to adhere to these norms.
- Currently, the vehicles that are being released in the market are Bharat Stage-VI (BS -VI) vehicles. This norm was effective from 1* April 2020.

Sound Pollution

- Air (Prevention and Control of Pollution) Act 1981, was amended in 1987 to include noise as an air pollutant.
- Sound level, **150 dB** or more may damage ear drum → Permanent hearing loss
- Effect noise : sleeplessness, increased heartbeat, altered breathing pattern

Water pollution and its control

- A mere 0.1 per cent impurities make domestic sewage unfit for human use



Sewage water

- Solids are easy to remove
- Dissolved salts such as nitrates, phosphates, heavy metals are most difficult to remove

1) Algal bloom

- Presence of large amounts of nutrients in water causes excessive growth of planktonic (free-floating) algae, called an algal bloom

2) Water hyacinth (Eichhornia crassipes)

- It is world's most problematic aquatic weed,
- Terror of Bengal
- They grow abundantly in eutrophic standing water bodies, and lead to an imbalance in the ecosystem dynamics of the water body.

3) Biomagnification

- Biomagnification refers to increase in concentration of the toxicant at successive trophic levels.
- This happens because a toxic substance accumulated by an organism cannot be metabolized or excreted, and is thus passed on to the next higher trophic level.
- Biomagnification is shown by **mercury and DDT**

Tg:- @chanpsjee_neet

Water (DDT 0.003 ppb)	→	Zooplankton (DDT 0.04 ppb)	→	Small fish (DDT 0.05 ppm)
Large fish (DDT 2 ppm)	→	Fish eating Bird (DDT 25 ppm)		

Higher the tropic level, higher will be the DDT concentration

Effect of DDT

- DDT disturb **calcium** metabolism in birds,
- Thinning of **eggshell** and their premature breaking,
- Eventually causing decline in bird populations.

4) Cultural or Accelerated Eutrophication

- **Eutrophication** is the natural aging of a lake by nutrient enrichment of its water. (Lake is converted to land over a period of time)
- Introduction of nutrients such as **nitrogen and phosphorus** radically accelerate the aging process called Cultural or Accelerated Eutrophication

5) Heavy metals

- Waste water from industries like petroleum, paper manufacturing, metal extraction and processing, chemical manufacturing, etc., often contain toxic substances, notably, heavy metals (defined as elements with density > 5 g/cm^3 such as mercury, cadmium, copper, lead, etc.)
- These heavy metals are most *difficult* to remove

A Case Study of Integrated Waste Water Treatment

Humboldt State University

- Waste water ⟶ conventional sedimentation, filtering and chlorine treatments are given ⟶ dangerous pollutants like dissolved heavy metals still remain, passed through ⟶ series of six connected marshes over 60 hectares of marshland having appropriate plants, algae, fungi and bacteria ⟶ These marshes absorb and assimilate the pollutants, remove **sludge**, also **remove heavy metals**
- These marshes also constitute **biodiversity** in the form of fishes, animals and birds
- A citizens group called Friends of the Arcata Marsh **(FOAM)** California, are responsible for the upkeep and safeguarding of this wonderful project

6) EcoSan toilets

- These are dry composting toilets.
- Human excreta is recycled into a natural fertiliser
- Implemented in many areas of Kerala and Sri Lanka.

Solid wastes

Solid wastes refer to everything that goes out in trash.

Municipal Waste

The municipal solid wastes generally comprise paper, food wastes, plastics, glass, metals etc.

Burning

Burning reduces the volume of the wastes, although it is generally not burnt to completion and open dumps often serve as the breeding ground for rats and flies

Sanitary landfills

- In a sanitary landfill, wastes are dumped in a depression or trench after compaction, and covered with dirt everyday
- Disadvantage: Chemical seepage and space is limited

Hospital wastes

- Hospitals generate hazardous wastes containing pathogenic organism
- Hospital waste is disposed using incinerator → Bohut Zyada Heat Ke upar Jalaya Jata hai.

Electronic wastes (e-wastes)

- E-wastes are buried in landfills or incinerated.
- Best solution: recycling of E-waste

Case Study of Remedy for Plastic Waste

Ahmed Khan, Bangalore developed Polyblend, a fine powder of recycled modified plastic.

- Polybend is mixed with the bitumen is used to lay roads.
- This increased road life by a factor of three

Radioactive wastes

- Two Major problems of radioactive waste: Accidental leakage and Safe disposal
- Accidental leakage incidents: Three Mile Island and Chernobyl
- Hazardous effects: mutation in DNA ⟶ cancer
- Safe disposal method : store in containers buried within the rocks about 500 m deep below the earth's surface
- Bhopal gas Tragedy is not an example of leakage of radioactive waste

Agro-chemicals and their effects

Use of inorganic fertilisers and pesticides affects non target organisms and may lead to eutrophication also.

Case Study of Organic Farming

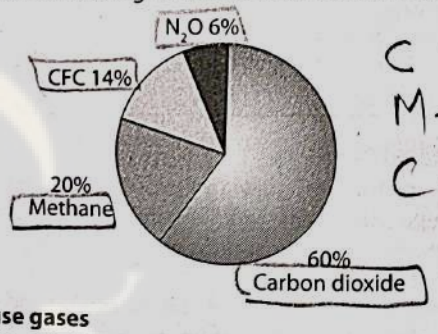
- Integrated organic farming is a cyclical, zero-waste procedure, where waste products from one process are cycled in as nutrients for other processes.

Ramesh Chandra Dagar a farmer included bee-keeping, dairy management, water harvesting, composting and agriculture in a chain of processes, which support each other and allow an extremely economical and sustainable venture

Greenhouse effect and global warming

Analogy with Green house and Car heating

The greenhouse effect is a naturally occurring phenomenon that is responsible for heating of Earth's surface and atmosphere.



C → 60
M → 20
C → 14

Greenhouse gases

- Carbon dioxide (major greenhouse gas), Methane, CFC, N_2O

Greenhouse effect

- 25% of solar radiations are absorbed by clouds.
- 25% of solar radiations get reflected.
- 50% of solar radiations heats the Earth's surface, gets reflected as infrared wave (heat wave).
- Greenhouse gases absorb and reemit infrared radiations raising the temperature of Earth.

Advantage of Green House effect

- Without greenhouse effect the average temperature at surface of Earth would have been a chilly -18° C rather than the present average of 15° C. -18°C → 15°C
- The greenhouse effect, leads to a mean surface temperature that is 33° C greater than it would be in its absence

Disadvantages of increase in level of Greenhouse gases

- The temperature of Earth has increased by 0.60c in past century, this heating of Earth is called "global warming"

Tg:-@chanpsce_meet

Effects of Global Warming

- Odd climatic changes (e.g. El Nino effect)
- Melting of polar and Himalayan ice caps, rise in sea level

How can we control global warming?

- Cutting down use of fossil fuel, improving efficiency of energy usage, reducing deforestation, planting trees

Ozone depletion in the stratosphere

Formation of Ozone

Ozone gas is continuously formed by the action of UV rays on molecular oxygen, and also degraded into molecular oxygen in the stratosphere.

$$O_2 \xrightleftharpoons{\text{UV rays}} O_3 \text{ (Ozone)}$$

Ozone is formed in Stratosphere → Good Ozone (absorb UV rays)

Stay good hai

Ozone formed in troposphere is called → Bad Ozone (affect health)

Thickness of ozone is measured in terms of Dobson units (DU)

Degradation of Ozone

- Chlorofluorocarbons (CFCs) used in refrigerant degrades ozone
- CFC reach stratosphere, UV rays act on CFC to release Cl atom
- Cl atoms degrades ozone releasing molecular oxygen
- Cl atoms act as catalyst and they have Permanent and continuing effects on Ozone
- Ozone depletion is particularly marked over the Antarctic region, commonly called as the **ozone hole**
- The ozone hole over Antarctica develops each year between late August and early October (**winter**)

Effects of degradation of Ozone

1. UV B is not reabsorbed → damages DNA → Skin Cancer
2. UV B also affects cornea → snow blindness
3. Also causes Cataract

An international treaty, known as the **Montreal Protocol**, was signed at Montreal (Canada) in 1987 (effective in 1989) to control the emission of ozone depleting substances.

Degradation by improper resource utilisation and maintenance

The degradation of natural resources can occur, not just by the action of pollutants but also by improper resource utilisation practices.

1. Soil erosion and desertification
2. Waterlogging and soil salinity

- Improper irrigation led to water logging
- Waterlogging draws salt to the surface of the soil, this salt is then deposited at the roots of the plants and decreases crop yield
- Waterlogging and soil salinity are some of the problems that have come in the wake of the **Green Revolution**

Deforestation

Deforestation is the conversion of forested areas to non-forested ones

Slash and burn agriculture (Jhum cultivation)

North east farmers cut down the trees of the forest and burn the plant remains → ash is used as a fertiliser → land is used for farming or cattle grazing → after cultivation, the area is left for several years so as to allow its recovery → with increase in population → the recovery phase is done away with, resulting in deforestation.

Consequences of deforestation

- **Enhanced carbon dioxide concentration** (Major effect)
- Loss of biodiversity
- Disturbs hydrologic cycle
- Soil erosion
- Desertification in extreme cases

Case Study of People's Participation in Conservation of Forests

King of Jodhpur, asked minister to arrange wood to construct new palace → Amruta Devi from Bishnoi community opposed cutting of tress → Amruta Devi, her daughters, fellow villagers had to lost their life to protect tress

Govt of India instituted ***Amrita Devi Bishnoi Wildlife Protection Award***

Chipko Movement

Garhwal Himalayas, local women showed enormous bravery in protecting trees from the axe of contractors by hugging them. People all over the world have acclaimed the Chipko movement

Government of India has introduced the concept of **Joint Forest Management (JFM)** so as to work closely with the local communities for protecting and managing forests

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NCERT Scientist and their discoveries

1.	Carolus Linnaeus	Binomial nomenclature, gave the two kingdom classification Plantae and Animalia
2.	R.H. Whittaker (1969)	Five kingdom classification
3.	Carl Woes	Proposed the 6 kingdom or 3 domain classification
4.	Ernst Haeckel	Proposed the three-kingdom classification – Protista, Plantae and Animalia
5.	Panchanan Maheshwari	Popularized the use of embryological characters in taxonomy
6.	Katherine Esau	Reported that curly top virus spreads through a plant via the food conducting or phloem tissue
7.	D.J. Ivanovsky (1892)	TMV Can pass through bacterial filter
8.	M.W. Beijerinck (1898)	Contagium vivum fluidum ("contagious living fluid")
9.	W.M. Stanley (1935)	Crystallized viruses
10.	T.O. Diener (1971)	Discovered viroid causing potato spindle tuber disease
11.	Bentham and Hooker	Natural system of classification
12.	Anton Von Leeuwenhoek	First saw and described live cell
13.	Robert Brown (1831)	Discovered nucleus
14.	Robert Hooke	Coined the term 'cell'
15.	Matthias Schleiden (1838)	Observed that plants are composed of different kinds of cells Gave cell theory with Schwann
16.	Theodore Schwann (1839)	Animal cells have plasma membrane Presence of cell wall is unique character of plant cell Gave cell theory with Schleiden
17.	Rudolf Virchow (1855)	"Omnis Cellula e Cellula" (All cells come from cells)
18.	Singer and Nicolson (1972)	Fluid mosaic model of cell membrane
19.	George Palade (1953)	Observed ribosome
20.	Camillo Golgi (1953)	Observed Golgi bodies
21.	Linus Pauling	Published models of the α-helix and β-sheet structures
22.	Ramachandran	Triple helical model of collagen
23.	Fleming	Stained nucleus by basic dyes and named it as chromatin
24.	Julian Von Sachs	Developed hydroponics (1860) Green parts are the site of photosynthesis in plants Proved when leaves are exposed to sunlight, they produced starch Chlorophyll is present in special bodies
25.	Joseph Priestly (1774)	Discovered oxygen, proved plant restore oxygen in air
26.	Jan Ingenhousz	Sunlight is essential for plant processes Only green parts of plant release oxygen
27.	T.W. Engelmann	Action spectrum of photosynthesis
28.	Cornelius van Nell	Studied green and purple Sulphur bacteria and demonstrated that hydrogen from a suitable oxidizable donor reduces CO2 to carbohydrates Oxygen released during photosynthesis comes from water (H2O)
29.	Hatch and Stack	HSK pathway or C4 Pathway
30.	Blackman	Law of limiting factor
31.	Embden, Meyerhof, Parnas	EMP pathway or glycolysis
32.	Charles and Francis Darwin	Coleoptile of Canary grass phototropism
33.	F.W. Went	Isolated auxin from oat coleoptile
34.	E. Kurosawa	Identified that foolish seedling disease was caused by the fungus Gibberella fujikuroi.
35.	Skoog and Miller	Discovered cytokinin
36.	Cousins	Conformed the released of a volatile substance (Ethylene) from ripened orange hastened the ripening of unripen banana
37.	Gregor John Mendel (1856- 1863)	Mendelian inheritance laws
38.	Reginald Punnet	British geneticist who discovered Punnett's square
39.	De Vries, Correns, Tschermak (1902)	Rediscovered Mendel's laws
40.	Sutton and Boveri	Chromosome theory of inheritance (chromosomes pass from one generation to the next, are the basis for all genetic inheritance.)
41.	T.H. Morgan	Linkage
42.	Alfred Sturtevant	Mapping of chromosome
43.	Henking	Discovered X-body
44.	Friedrich Miescher	DNA present in nucleus is an acidic substance ⊠ called it nuclein
45.	Watson and Crick	Double helix model (B-DNA)
46.	Wilkins and Franklin	Used X-RAY diffraction technique to study DNA

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47.	Erwin Chargaff	A + T / G+C = 1, Stated the ratios between adenine and thymine, and guanine and Cytosine are constant and equal to one.
48.	Avery, MacLeod, McCarty	DNA is responsible for transformation
49.	Hershey and Chase (1952)	Unequivocal proof that DNA is the genetic material (bacteriophage and E Coli)
50.	Francis Crick	Central Dogma of protein synthesis
51.	Meselson and Stahl	Proved Semi conservative nature of DNA replication (E Coli, N15)
52.	Taylor	Proved Semi conservative nature of DNA replication in Vicia faba
53.	George Gamow	For 20 amino acids, 43 = 64 codon
54.	Marshall Nirenberg	Cell free system for protein synthesis
55.	Har Gobind Khorana	Synthesized RNA molecules with defined combinations of bases (homopolymers and copolymers)
56.	Severo Ochoa	Severo Ochoa enzyme (polynucleotide phosphorylase) ⟶ polymerized RNA with defined sequences in a template independent manner (enzymatic synthesis of RNA)
57.	Jacob and Monad	Explained Lac operon
58.	Frederick Sanger	Discovered method for determination of amino acid sequence in proteins
59.	Alec Jeffrey	Developed principle upon which automated DNA sequencers work
60.	Bolivar and Rodriguez	Developed DNA Fingerprinting
61.	Louis Pasteur	Constructed the pBR322 cloning vector.
62.	Oparin and Haldane	Disproved abiogenesis, stated Life originate from pre-existing life
63.	S.L. Miller (1953)	Coined the term virus
64.	Alfred Wallace	Proposed chemical evolution of life
65.	Ernst Haeckel	Miller experiment (provided the first evidence that organic molecules needed for life could be formed from inorganic components – organic evolution)
66.	Lamarck	Reached same conclusion as that of Darwin — Malay Archipelago
67.	Karl Ernst von Baer	Ontogeny recapitulates phylogeny (theory of recapitulation)
68.	Thomas Malthus	Use and disuse of organ ⟶ evolution
69.	Hardy and Weinberg	Disproved Ontogeny recapitulates phylogeny
		Theory of Population Growth
		Stated that allele frequencies in a population are stable and are constant from generation to generation.
70.	Hugo de Vries	Mutation theory of Evolution (Oenothera lamarckiana - evening primrose)
		Gave the concept of Saltation

Organisms used by Scientists

1.	Engelman	Cladophora (green algae)
2.	Priestley	Mint plant
3.	Van Neil	Purple and green sulfur bacteria
4.	Melvin Calvin	Algal photosynthesis, 14 C
5.	Charles Darwin, Francis Darwin	Canary grass
6.	F W Went	Oats (Avena Sativa)
7.	F Kurosawa	Gibberela Fujikuroi
8.	Skoog	Tobacco plant
9.	Cousins	Used oranges and banana
10.	Mendel	Garden Pea (Pisum Sativum)
11.	T H Morgan	Drosophila Melanogaster
12.	Griffith	Streptococcus Pneumoniae
13.	Hershey and Chase	Bacteriophage and E Coli , Used sulfur-35 (to label protein) and phosphorus-32(to label DNA)
14.	Meselson and Stahl	E Coli , used heavy isotope (nitrogen-15)
15.	Taylor	Vicia faba , used radioactive thymidine
16.	Jacob and Monad (Lac operon)	E Coli
17.	Hugo de vies	Evening primrose
18.	Cohen and Boyer	Salmonella typhi and E Coli ⟶ rDNA
19.	Connell's Elegant field experiment	Barnacle Balanus and barnacle Chathamalus
20.	Mac Arthurs	Warblers
21.	Alexander Fleming	Staphylococcus bacteria

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Abbreviations

CPCB	Central Pollution Control Board
cDNA	Complementary DNA
Complex I	NADH dehydrogenase
Complex II	Succinate dehydrogenase
Complex III	Cytochrome bc1 complex
Complex IV	Cytochrome c oxidase complex
CNG	Compressed Natural Gas
FOAM	Friends of Arcata of Marsh
JFM	Joint Forest Management
IARI	Indian agricultural Research Institute
PMNL	Polymorphonuclear Lymphocytes
MALT	Mucosa Associated Lymphoid Tissue
EST	Expressed sequence Tag
VNTR	Variable Number Tandem Repeats
BAC	Bacterial Artificial Chromosome
YAC	Yeast Artificial Chromosome
MTP	Medical Termination of Pregnancy
NACO	National AIDS Control Organization
MOET	Multiple Ovulation Embryo Transfer Technology
IVF	In vitro Fertilization
GIFT	Gamete intra fallopian transfer
ZIFT	Zygote intra fallopian transfer
ICSI	Intra Cytoplasmic Sperm Injection
IUI	Intra Uterine Insemination
MMR	Maternal Mortality rate
IMR	Infant Mortality rate
RCH	Reproductive and Child Health Care
MRI	Magnetic Resonance Imaging
CT Scan	Computed Tomography Scan
KVIC	Khadi and village industries commission

Notes:

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Places

Indian Botanical Garden	Howrah (India)
Central Drug Research Institute (CDRI)	Lucknow
Sahiwal Cow bred in	Punjab (through artificial selection)
Hisardale (Sheep) develop in	Punjab (Bikaneri ewes and Marino rams cross breeding)
IARI	Delhi
Rauwolfia vomitoria grow in	Himalaya
Dodo extinct from	Mauritius
Quagga extinct from	Africa
Thylacine extinct from	Australia
Steller's sea cow extinct from	Russia
Montreal Protocol held in	Montreal (Canada)
Ozone hole is marked over	Antarctic region
Keolado National Park	Bharatpur (Rajasthan)

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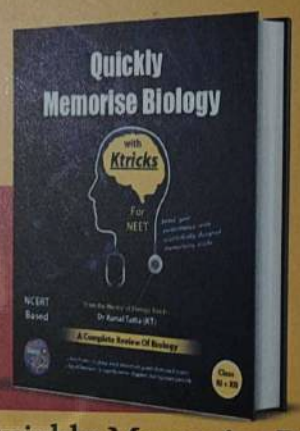

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